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An Illustrated Weekly Journal.

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Applications must be made by TUESDAY, 20th MARCH, 1923.

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T. B. TURNER, Secretary.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND,
16, Bedford Square,
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January, 1923. X 636

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Academic Registrar.
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Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m. on Friday, the 9th March, 1923.

T. RYAN, Director-General. X 619

H.E.H. THE NIZAM'S GUARANTEED STATE RAILWAYS COMPANY, LIMITED.

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For each copy of the Specification a fee of Ten Shillings will be charged, which is not returnable. Tenders, enclosed in sealed envelopes endorsed "Tender for Locomotives," and addressed to the Chairman and Directors, must be delivered at the Company's Offices not later than Twelve Noon on Friday, 9th March, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
F. ADAMS, Secretary.

Winchester House,
50, Old Broad Street,
London, E.C. 2.
15th February, 1923. X 646

TENDRING HUNDRED WATERWORKS COMPANY.

The Directors are prepared to receive

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The Specification may be obtained (on payment of Two Guineas, returnable if a *bona fide* Tender be made) on application to the Company's Secretary.

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HENRY BURROWS, Secretary.

Manningtree, Essex. X 613

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BARKING POWER STATION.

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F. O. McQUOWN, Manager and Secretary. X 565

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Moorgate Court, Moorgate Place, E.C.

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No. 13.—Laminated Springs ...	10s.
No. 14.—Lamp Glasses, &c. ...	2s. 6d.
No. 15.—Plate Glass	5s.
No. 16.—Wicks	2s. 6d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Work for Bridges" or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 27th February, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.

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London, 14th February, 1923. X 634

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LITERATURE.

Hydro-Electric Engineering. Vol. II. *Electrical.* Edited by A. H. GIBSON, D.Sc., M.Inst.C.E. With Contributions from W. ANSELM COATES, M.I.E.E.; F. E. HILL, A.M.I.E.E.; and SIDNEY NEVILLE, B.Sc., A.M.I.E.E. London: Blackie and Son, Limited. [Price 30*s.* net.]

IN the first volume of this work which was published the year before last, and reviewed in our issue of November 25, 1891, attention was confined mainly to the methods of collection, conveyance, storage and management of water to be utilised in a scheme designed for the furtherance of hydro-electric development. The theories of the turbine and Pelton wheel, with the description of the various forms in which they were used, prepared the way for the construction of mechanism adapted for the transference of mechanical into electric energy. In this volume that step is made, and the study of a complete installation is possible, illustrated by ample reference to plant that has been found to work satisfactorily both in Europe and America, and to the practice that is followed at large operating centres. In the present state of industrial enterprise, when the possibilities of hydro-electricity are claiming a fuller recognition, such a comprehensive survey of a mass of practical detail, illuminated by the comments of trained experts, cannot but be welcome, for the amount of technical literature devoted to this subject has hardly been commensurate to its importance, owing to the opportunities of acquiring information and practice in this country being few in number and limited to small outputs of energy. The appearance of these volumes is rendered especially timely, as it coincides with the increased attention now being paid to further development. And here, perhaps, it may be permitted to say that none has done more than Dr. Gibson to dispel the indifference long exhibited by the public in the possibilities of utilising water as a source of power. He it was who, in his capacity of secretary to the Water Power Committee of the Conjoint Board of Scientific Societies, collected the information that guided the Committee, and it was to his indefatigable efforts that we owe the three instructive reports, which have convinced the public that in the water of our streams and lakes we possess a potentially utilisable amount of water power of more than 1,000,000 h.p., an amount by no means negligible in comparison with the total expenditure of energy derived from fuel-operated plant. This estimate does not include the power derivable from the possible utilisation of tidal waters in conjunction with a judicious system of storage. This subject was discussed in some of its aspects in the first volume, and Dr. Gibson, correctly appreciating the public and professional interest awakened by the project, returns to the topic again, but before the scheme reaches the financial stage, much preliminary spade-work will have to be done. It is, however, encouraging to note that far greater readiness exists to examine systematically the sources of our possible water power than was apparent in those days, when, with a cheap and well-distributed supply of fuel, there seemed, in the absence of visible powerful heads of water, little prospect of generating and little desire to produce power that could compete in price with that obtained from coal.

Familiar problems connected with the generation and transmission of electricity cannot be entirely excluded from those arising from the use of hydro-electric plant, and at the outset it is evident from Mr. Neville's contribution on Water Wheel Generators, that some of the differences and many of the difficulties, mechanical as well as electrical, arise from the magnitude of the forces which have to be handled. Moreover, a definite or simple solution of any problem presented is usually impossible. Judgment and decision often depend upon the nice balancing of the advantages and disadvantages of alternative plans. Experience frequently proves a safer guide than theory, when the answer to the problem is to be expressed in available dividends. The question of the selection of a suitable generator confronts us at the outset. Should low-frequency be preferred to high frequency, with similar output? Theory will demonstrate that the low-frequency machinery must be heavier and more expensive than the high. Other considerations have their influence, the short circuit forces are greater and the effective clamping of the windings is more difficult. Practice and experience argue that these disadvantages are more than counterbalanced by reductions in the charging current and pressure drop in the transmission line, thereby increasing its current-carrying capacity. Again, single-phase supply seems attractive by its greater simplicity of equipment, till the loss involved in the generators and the generally less reliable performance are brought into the account. The nature of the load to be supplied may again make the balance turn in the opposite direction. The pre-eminence gained for energy generated as alternate current by reason of its simplicity and readiness with which it can be transformed to higher pressure for economical transmission may be challenged by high-tension direct-current transmission, notwithstanding the essential difficulties of its generation. It is one of the merits of this work that the choice of apparatus, and the reasons for selection, are put prominently forward and compared with modern practice. The description of mechanism is also most elaborate, as shown in the chapter on alternators.

Mr. F. E. Hill writes on the construction and operation of transformers, the mechanism that has proved so effective in transmitting electric energy to stations remote from the place of generation. He is particularly concerned to describe the designs for construction and insulation of transformers known as the "core" and "shell" types, according to the relative position of the magnetic circuit and the windings. These are fully described and illustrated, as are also the various methods adopted in cooling, whether by water, where the supply is ample, or oil immersed in connection with special devices. Except in matters of detail opportunities for originality of treatment are few. The advantages claimed for the various forms of transformer and equipment, and the modifying effects that large output may necessitate on the selection of type, are clearly stated. The author is not able to see any great superiority in either of the two main forms of "core" and "shell" type, but he remarks that one firm claims to have overcome what has been urged as a defect in the "core" transformer. Under the continual heating and cooling, in practice, the insulating material used in the windings has been found to contract, preventing the coils being clamped tightly, unless the supports have been adjusted to take up the skrinkage. This imperfection in manufacture it is asserted is removed by thorough shrinking of the coils before leaving the factory, but Mr. Hill doubts whether "windings on large and high voltage transformers can be so thoroughly shrunk during manufacture as to prevent any further shrinkage in service."

The third section is entrusted to Mr. Coates, whose contribution is very valuable, as it illustrates many points of American practice connected with protective systems in high voltage arrangements, lightning arresters, and switch-gear lay-out. Many passages show close connection with hydro-electric stations, and references are made to particular instances. The underlying principles that decide the selection of appropriate equipment are discussed, but it is not possible to insist on any one form as more suitable than another approved method, owing to the many factors and variables that enter into the problem. But, in passing, we note that in America when a device proves ineffectual or disappointing in its operation there is a tendency to dispense with it, though the necessity for some substitute may be patent. For securing the automatic operation of circuit breakers, the early forms of relay proved unreliable and their use was abandoned, so that many large plants exist without any automatic switches, though entirely trustworthy relays have been on the market for some years. One would scarcely recommend this practice of escaping from a difficulty, however well it works in particular cases. To counteract any wrong impression this remark might create, we may refer to another plan which has much to recommend it. In another connection, the author describes a simple device that materially assists the selection of sub-station circuit breakers. A model of the electric system is constructed, using resisting coils to represent the various sections of the line. A known voltage is impressed across the model, and the division of the current gives a direct guide to the breaking capacity required at any point. Many other useful arrangements are described which, if we could refer to them, would demonstrate the practical character of the work.

The two concluding chapters are from Dr. Gibson on the economics of hydro-electric development and the application of the principles to tidal oscillations, as illustrated by a possible installation in the Severn Estuary. In the simplest manner, he states the principles on which alone a scheme can prove a commercial success, and is under no misapprehension of the difficulties that any proposal will have to face and overcome. He submits the loose and somewhat optimistic views of irresponsible guides to the stern arbitrament of actual statistics drawn from the published balance sheets of Canadian companies, who have had the advantage of acquiring land at prairie value, and little to fear in the way of active competition. It is idle to point out that the nation is allowing a valuable asset to run to waste by neglecting tidal movement, while the coalfields are being extravagantly depleted—a favourite theme with some—unless it is explained how that force is to be utilised. At present there is no market for such power, only new undertakings can utilize the energy, and there are but few signs of these forthcoming. Steam-power plants will fight the advent of the new force jealously, and those who might be possible consumers, being already supplied with machinery, will be slow to scrap the familiar forms and deprive themselves of trained skill, for the prospect of a hypothetical gain that will be certainly small, and a novelty whose merits are uncertain.

Apart from the commercial success there are, however, many interesting problems that arise in considering the novel scheme of harnessing the tides. Some of these, more particularly concerned with hydraulics, were discussed in the earlier volume. Dr. Gibson now carries the inquiry a stage further, but we can only quote a few of his results. Matured reflection has convinced him that multiple basin systems must be excluded, as outside the limits of practicability, and that the only schemes likely to lead to a successful issue must be based on the use of a single basin developing power on both rising and falling tides, or on the outflowing tide only. Assuming that the tidal basin has an area of 1 sq. mile, that the water surface is sensibly level at all stages of the tide, that the range at spring tides is 42 ft., that 5 hours are occupied in rising and 7·5 in falling, that at neap tides the range is 16 ft., and that the time consumed in rising equals that in falling, it is possible to form a very definite idea of the power that would become available. Three cases may be considered, first, working on a falling tide only—the least favourable case—and making the usual allowance for loss in storage supply, the output may amount to 7,680 b.h.p. continuous 24-hours' working. In the second case, operating on rising and falling tides under natural head, the output rises to 12,400 b.h.p. Finally, if the scheme be arranged to work with rising and falling tides with constant rates of rise and fall in basin, a maximum output of 13,150 b.h.p. is attained if all the energy is absorbed. In these estimates it is assumed that the primary turbines have a mean efficiency of 75 per cent., but this value may be too high, for under the extreme variations of head that are the consequence of a tidal flow, the efficiency of any constant speed turbine falls off rapidly, especially at the lower heads, though in modern work this defect is less noticeable, and very gratifying results have been achieved that will naturally be surpassed in the near future.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

By W. NOBLE TWELVETREES, M.I.Mech.E., A.M.I.E.E., M.Soc.C.E. (France).

(*Continued from page* 137.)

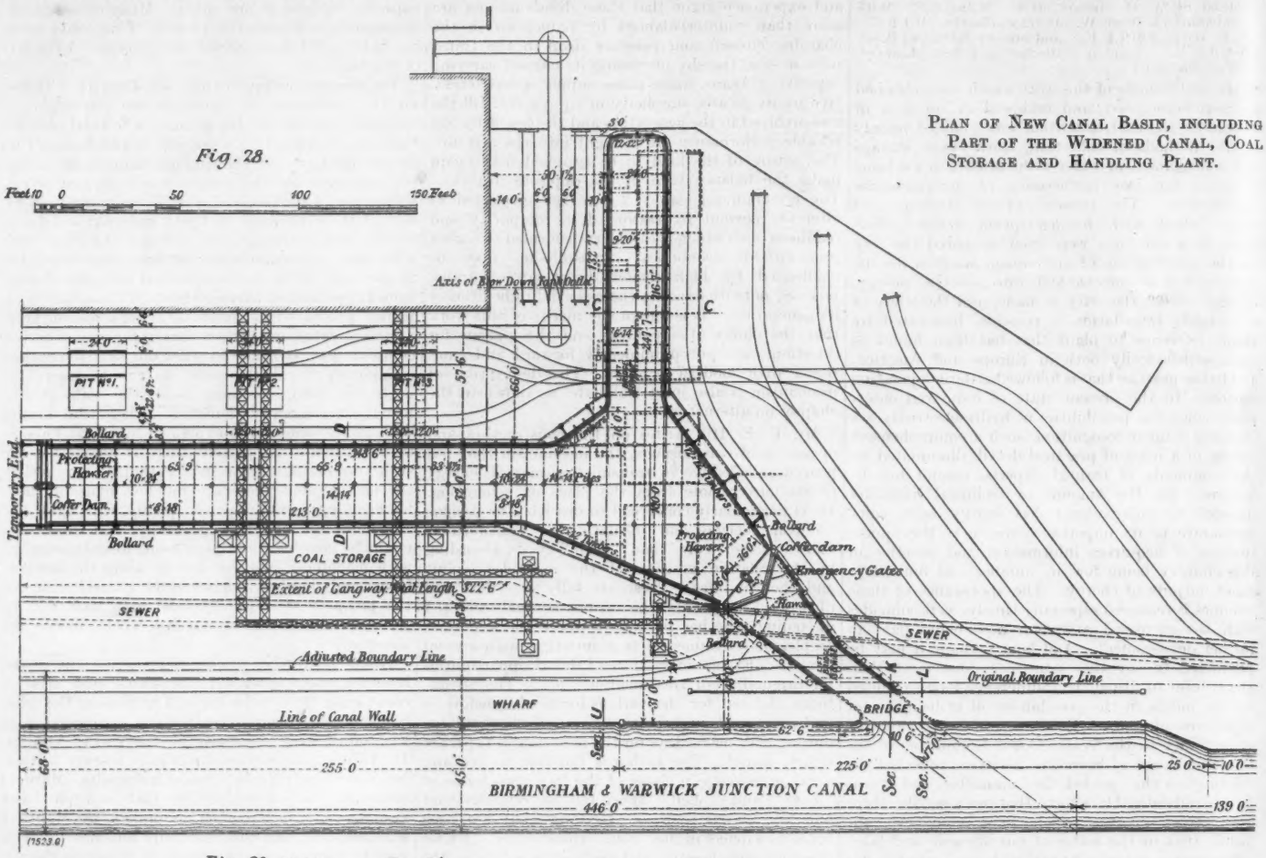
Canal Widening Works.—From Salford Lock opposite the middle of the coal storage area to the other end of the site, the Birmingham and Warwick

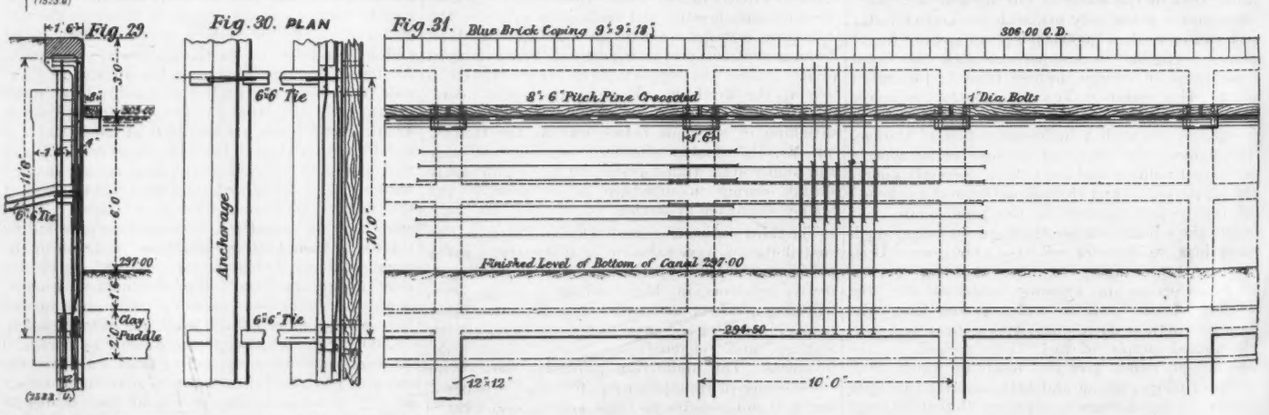
Junction Canal has been widened from 34 ft. to 45 ft. by building a new wall in reinforced concrete, removing the old wall, dredging out the channel and making the bottom watertight with a 2-ft. bed of clay puddle. The widening is clearly shown in the general plan, Fig. 3 on Plate VI published with our issue of January 26, and in Fig. 28 above. The new wall, about 1,350 ft. in length, consists of a row of 12-in. piles driven at intervals of 10 ft. apart, trimmed off level at the top and connected by continuous beam spans; the piles are continued upward in the form of columns and connected at the top by another series of continuous beam spans; the framed structure so formed is completed by a 4-in. continuous vertical slab, the whole of the work having been executed on the monolithic principle. Details of the wall and piles are given in Figs. 29 to 36, annexed. The new wall is anchored back by land ties secured to concrete blocks embedded in the earth, as shown in Fig. 37, on page 195. The coping is formed of blue brick, and reinforced brackets are moulded on the columns for the attachment of pitch pine fenders in order to protect barges from damage when coming alongside the new wharf. This detail is clearly illustrated in Figs. 32 to 34.

Road Bridge on Canal Front.—Near the end of the new canal wall, reinforced concrete has been applied in the construction of a road bridge crossing the entrance to the new canal basin, to which reference is made below. The position of the bridge is clearly shown in the plan of the canal basin shown in Fig. 28. The bridge has a skew span of 17 ft. measured at right angles to the channel and 27 ft. 6 in. measured parallel to the canal wall; the width is 12 ft. between parapets, and the total length including approaches is 221 ft. The approaches rise on each side with an easy gradient of 1 in 12, and are in reality reinforced concrete viaducts

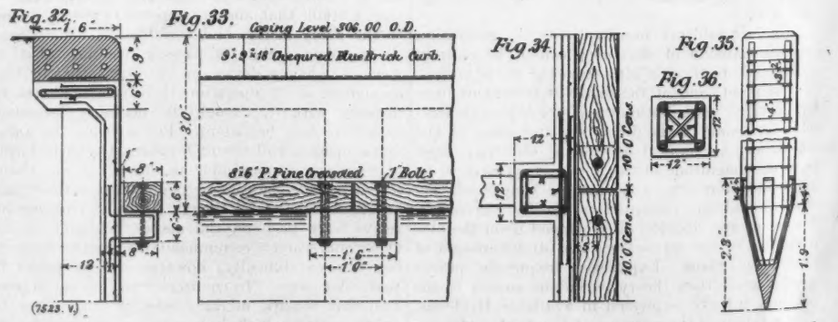
Fig. 28.

PLAN OF NEW CANAL BASIN, INCLUDING PART OF THE WIDENED CANAL, COAL STORAGE AND HANDLING PLANT.





FIGS. 29 TO 36. DETAILS OF NEW CANAL WALL.



consisting of piles, pillars, tie beams, parapet beams and wall panels. On the canal side the approaches are carried up in continuation of the new canal wall, and on the landward side the framework was left without filling the panels, so as to facilitate the deposition of earth used as filling to bring the ground surface up to the new level. The span from the original ground level, which is several feet below the level of water in the canal, and still more below the top of the canal bank. After the completion of the new canal wall and the new canal basin, the ground was levelled up by filling, as previously mentioned in connection with the coal pits.

Fig. 37. SECTION J. (Fig. 28)

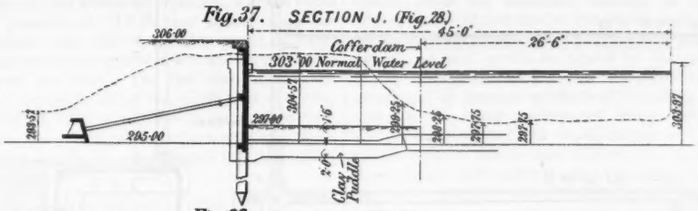


Fig. 38. SECTION L. (Fig. 28)

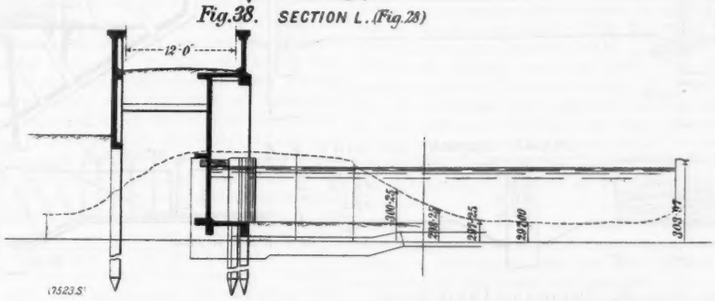
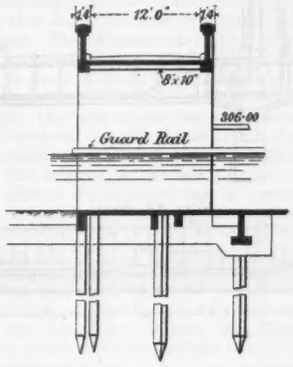
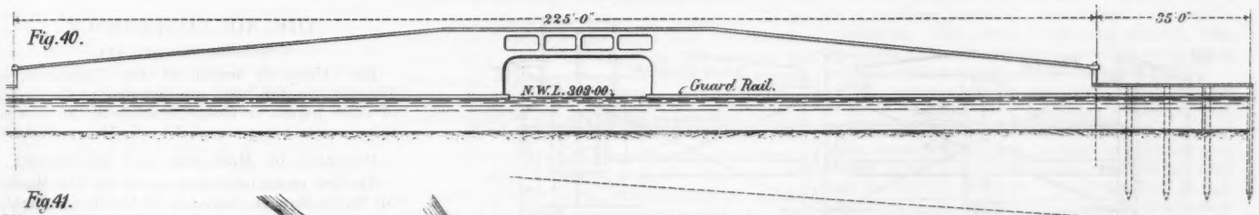
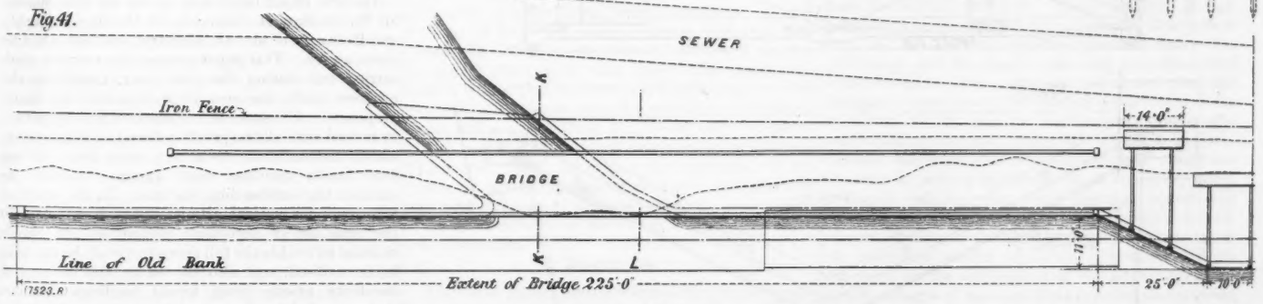
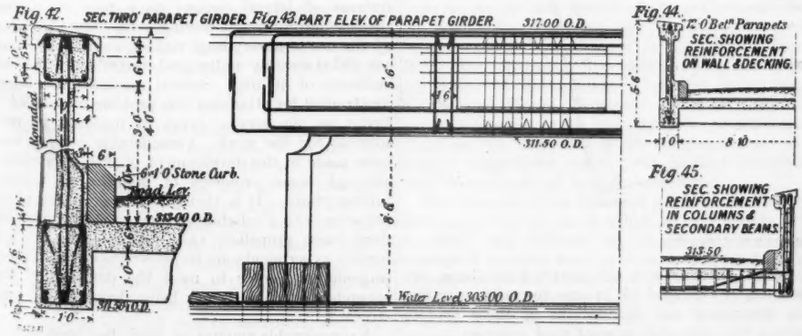


Fig. 39. SECTION K.









FIGS. 38 TO 45. DETAILS OF CANAL WALLS AND BRIDGE.

across the canal entrance channel is formed by two parapet girders, 5 ft. 6 in. deep, a series of seven transverse beams and a continuous deck slab. An elevation and plan of the bridge and various illustrations of the details of its construction are given in Figs. 38 to 45, on the present page.

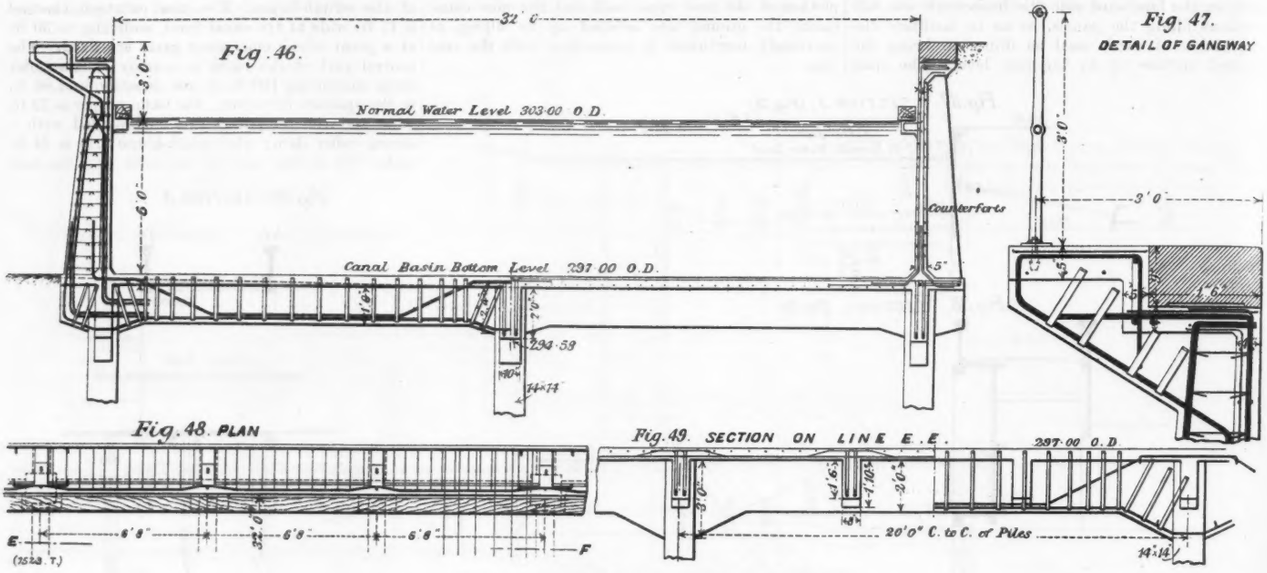
New Canal Basin.—The works included under this head are of much interest, and serve to demonstrate the convenience and suitability of reinforced concrete for canal channels and locks. In this particular case, the whole of the work was executed

According to the complete scheme, the new canal basin will be a little over 1,000 ft. in length, having an entrance channel at each end, each of the channels terminating in an enlarged area for the manipulation of barges, and the main portion of the basin being of uniform width. Provision is also made for an arm from the southern basin to within a few feet of the switch-house. The arrangement is clearly shown in Fig. 28.

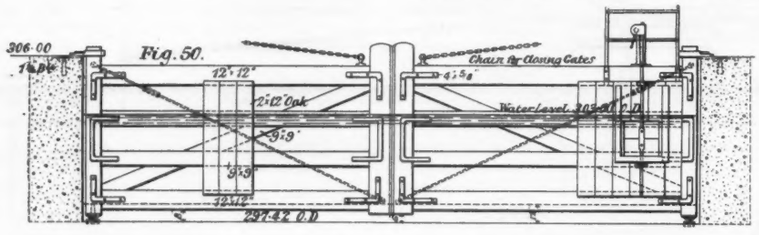
The work so far executed comprises the new southern entrance channel with enlarged area, whence extends the first portion of the main basin, 213 ft. in length, in the direction of Salford Lock, and the eastern arm, 116 ft. long, in the direction of the switch-house. The new entrance channel is 17 ft. wide at the canal front, widening to 30 ft. at a point where emergency gates are fixed. The central part of the basin is roughly of triangular form, measuring 100 ft. in one direction and 80 ft. in the opposite direction; the basin proper is 32 ft. wide and the temporary end is provided with a strong coffer dam; the switch-house arm is 24 ft. wide. As in the case of the coal pits, the new canal basin was constructed entirely above original ground level and after its completion the ground was filled up to coping level.

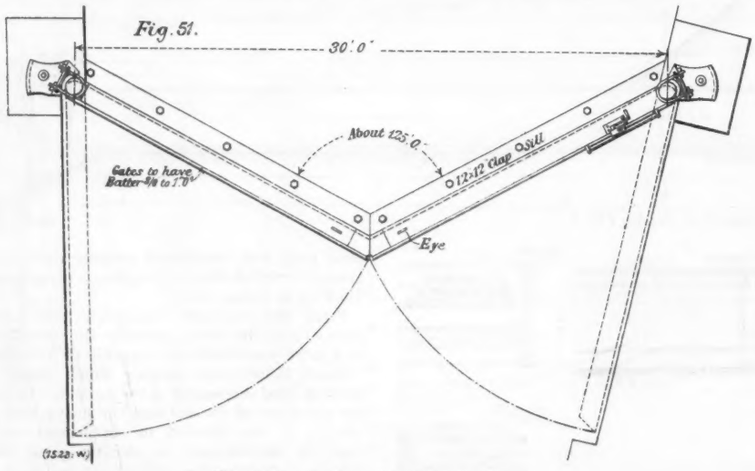
From the structural standpoint, the entrance channel and the basin generally are virtually akin to a large open reservoir, capable of withstanding without injury any stresses which might arise through local settlement of the ground. In view of the character of the soil and the heavy load to be carried, it was decided to supplement ordinary reservoir foundations by driving piles beneath the counterforts in the side walls as well as in intermediate rows, all the piles being connected at the head by beams. The bottom of the basin and channels consists of longitudinal and transverse beams and continuous slabs, 5 in. thick. The side walls, 9 ft. high, rise from longitudinal beams, and consist of 5-in. vertical slabs, reduced to 4 in. thick at the top, stiffened by counterforts at intervals of 6 ft. 6 in. apart. Around the triangular portion of the basin, the counterforts are of greater depth than elsewhere, and rise from footing slabs, 5 ft. from front to back, supported on double rows of piles. The sides of the basin are finished by longitudinal members with special provision for the reception of the blue brick coping, and cantilever brackets are moulded on the inner face of the walls for the attachment of timber fenders, as in the case of the new canal wall. The depth of water in the entrance channel and basin is 6 ft. Details of the

CANAL BASIN: NECHELLS POWER STATION, BIRMINGHAM.



Figs. 46 to 49. Details of Canal Basin.





Figs. 50 and 51. Emergency Gates.

construction of the basin are given in Figs. 46 to 49, on the present page, while the emergency gates are shown in Figs. 50 and 51, annexed. A series of photographic views showing various stages in the construction of the basin are given in Figs. 52 to 55, on page 308 of the present issue.

Sewer Crossing under Entrance Channel.—One of the new sewers on the site passes beneath the new entrance channel. The sewer was constructed in an excavation made before the commencement of the channel, which was afterwards built over the sewer. The portion of the sewer passing below the channel is 65 ft. in length, and is of elliptical section, 10 ft. wide and 7 ft. high at each end, tapering down to 5 ft. 6 in. high in the middle portion, 38 ft. long under the channel; this part is founded on two rows of piles, connected by transverse beams. The entrance channel and the switch-house arm are spanned by two steel lift bridges for railway traffic, the abutments and foundations of these bridges having been executed in reinforced concrete.

(To be continued.)

Congres du Chaufflage Industriel.—A Congress on Industrial Heating is announced to take place from June 10 to June 16, at the Conservatoire National des Arts et Métiers, Paris; in connection therewith an exhibition will be held at the same place from June 1 to June 17 of apparatus bearing upon the production, conservation and recuperation of heat in industry. The exhibits may consist of patterns, drawings, or, if space permits, of complete apparatus. The hon. president of the congress is Mr. Le Chatelier; the president, Mr. Walckenaer, Chief Inspector of Mines. The offices are at the Ministry of Public Works, 246, Boulevard St. Germain, Paris 7.

THE AIR CONFERENCE.

(Concluded from page 184.)

The afternoon session of the Conference, on Tuesday, the 6th inst., was devoted to the reading of three papers on technical subjects, the chair on this occasion being occupied by Sir Henry Maybury.

Progress of Research and Experiment.

The first paper taken was one by Air Vice-Marshal Sir W. Geoffrey H. Salmond, Air Member for Supply and Research, of the Air Ministry, and bore the title given above. This paper reviews the research work carried out during the past year, describing the progress made, the present position and the future proposals. The space at our disposal will not permit us to deal with all the points referred to in the paper, which naturally covers a very wide field, but we may briefly mention what appear to us to be some of the outstanding features. In the study of aerodynamics special attention has been given to the question of aeroplane control at low speeds in order to enable the full speed range of the machine to be utilised, and also to reduce the chances of accidents arising from forced landings. Various systems of lateral control have been tried, the greatest improvement having been obtained so far by the use of a very large rudder, and an aeroplane has glided steadily under good control at an angle of incidence of 40 deg. Special machines are being constructed for attacking this problem of "stalled" flying, as the service types of machine are unsuitable for the work. Considerable progress has been made in the development of metal propellers, although some problems of manufacture require further study. It is thought that a variable-pitch propeller with a reliability equal to that of existing fixed-blade propellers can now be designed, but further experiments are to be carried out with these propellers in order to meet the demands of the supercharged engines now being designed and constructed.

A considerable amount of work has been carried out on aeroplane under-carriages, of the Oleo type, in which the use of rubber in tension, and in exposed positions, is avoided. Four types have been evolved, and in three of these rubber has been entirely eliminated, while, in the fourth, it is only employed for buffers. The experiments are still in progress, but the last-mentioned type has already proved entirely satisfactory. A large programme of work is in hand in connection with variable-camber gears and similar devices intended to increase the useful weight carried by aeroplanes. Work is also being continued in connection with the metal construction of aeroplanes, mainly for the

purpose of simplifying designs so as to enable machines to be produced at a commercial price and in reasonable quantities. In connection with aero engines, one of the most interesting features referred to in the paper is the development and use at the Royal Aircraft Establishment of a single-cylinder aero engine operating on the Diesel cycle. Using shale oil fuel with solid injection, a brake mean effective pressure of 112 lb. per square inch has been obtained, and with an engine speed of 1,000 r.p.m., the fuel consumption was 0·415 lb. per brake horse-power per hour. The fuel cost, it may be mentioned, would be about one-ninth that of petrol. Many other interesting matters in connection with engines, machines, navigating instruments, materials, inspection methods, &c., are referred to in the paper, but these we must pass over.

THE USES OF GLIDERS.

The next paper taken was one by Colonel A. Ogilvie, bearing the title "Gliders and their Value to Aeronautical Progress." In this, the author first referred to the early experiments with gliders, dealing particularly with the work of Lilienthal, which he regarded as of the utmost importance. The want of success with the early attempts at flight, the author ascribed to lack of control in the air, and he pointed out that three years' work on the part of the Wright brothers, using gliders and models, was required to solve the control problem. The glider, he added, had provided a means of arriving at the fundamentals of this problem in a simple, inexpensive and reasonably safe manner. Dealing briefly with the subsequent development and present position of aviation, the author described the latter as practically a deadlock, since for the production of really sound and economical aircraft a large volume of experimental work was necessary, but the cost of this work was quite beyond the capacity of the transport firms or of the aircraft industry.

After giving a short account of the more recent experiments with gliders, the author expressed the opinion that there was little likelihood of engine-less aeroplanes ever being of practical utility in travelling from place to place or even of being employed to any extent for sport. Their real and immediate value, he said, was the opportunity they afforded of making technical experiments in a simple and inexpensive manner. For this work, gliders had the advantage that the motive power used was gravity, and was thus perfectly definite in amount and always reliable. The two main technical problems in connection with the development of the commercial aeroplane at the present time were the increase of aerodynamic efficiency and the improvement of control at low flying speeds. The author thought there could be little doubt that substantial progress would be made in solving these, and other problems in aeronautics, by means of experimental work with gliders. Finally he appealed to business men and others to offer prizes for such work in order to stimulate competition and thus hasten progress.

SEAPLANES.

The last paper on the programme was that by Mr. C. R. Fairey, on "Seaplanes." In this the author pointed out that unlike the aeroplane, the design of the seaplane was still in an unsettled state, even as regards the accepted general arrangement of the components, and there were also quite sharply divided opinions as to the relative merits of different types. After dealing briefly with the advantages of seaplanes from the commercial and naval standpoints, the author compared the various types from the point of view of seaworthiness, both under power and drifting. He pointed out that the qualities which made for improvement in one case were frequently disadvantageous in the other, and concluded that seaworthiness was largely a matter of size, the larger sizes allowing a greater margin of weight to be used for improving their seaworthiness and local strength. The present methods of handling seaplanes in launching them and bringing them ashore the author described as deplorable, and he regarded them as the chief obstacle to the more extended employment of this class of aircraft. A machine was usually brought up to the slipway, and a special beach axle, shaped to the bottom of the float or hull, was placed in position by men in waders, the machine then being hauled ashore by winches or hand power. The operation was costly and greatly damaged the machines. Of the various possible improvements, the author described a tidal slipway and a floating shed, both suggested by Mr. O. Short.

The author also mentioned that it would be advantageous for seaplane stations to be constructed with canals and a system of locks leading right into the sheds. The original cost of such a station, he said, would be repaid by the reduction in the damage to the hulls as compared with that occasioned by present methods of handling. With regard to the many problems of design, the author said he proposed only to touch on one or two outstanding points which most affected the comparison of seaplanes with aeroplanes. Of these, the most important was the water resistance of the hull or floats, and a common characteristic of both was that the resistance rose rapidly with the speed to an initial maximum, known as the "hump" speed, afterwards falling more or less. This feature necessitated the allowance of a margin of power so that the machine could pass the hump speed with a reasonable acceleration, and also affected the propeller design, since it was necessary to obtain a considerable thrust at low forward speeds with a correspondingly bad effect at the top speed of the machine.

This question could be dealt with either by employing a variable-pitch propeller or by providing a two-speed gear on the engine. The remainder of the paper was occupied with a comparison of the weights of seaplanes and aeroplanes with the object of showing the advantage of the boat-type seaplane in the larger sizes. The author exhibited a curve on which he had plotted the percentage of the structure weight on a base of total weight for various existing aeroplanes, twin-float seaplanes and boat seaplanes. From this he drew the deductions that the advantage lay with float-type seaplanes for small machines and with the boat-type for large machines, and also that the performance of large flying boats would be superior to that of large aeroplanes. Large float-type seaplanes, he thought, also showed sufficient promise to justify experiment with them. The paper concluded with a plea for further full-scale experimental work with seaplanes, pointing out that problems of seaworthiness, handling, &c., could only be solved in this way and adding that even now, after seaplane flying had been carried on for upwards of ten years, no proper comparison had ever been made of the seaworthiness of various types.

At the conclusion of Mr. Fairey's paper the session was adjourned.

DISCUSSION.

The three papers above referred to were discussed together at the last session of the conference, held on Wednesday afternoon, the 7th inst., the chair being taken by Sir William Joynson-Hicks, Bart. M.P. The chairman first called upon His Grace the Duke of Sutherland, to read a letter from Sir Samuel Hoare, Secretary of State for Air, expressing regret at his inability to be present, and thanking the members of the conference for the helpful suggestions made. Sir Samuel promised that these should all be duly considered.

The chairman then delivered a brief introductory address, in the course of which he appealed to the Secretary and Cabinet not to economise at the expense of research work as it was necessary for this country to be far ahead of others in this respect. He also referred to the many notable advances in aviation made during the last ten years, and expressed the view that progress would be at least as rapid during a similar period of the future.

Professor L. Bairstow, the first speaker in the discussion, confined his remarks to the subject of research, pointing out that the weak point lay in the lack of facilities for full-scale work. He was glad to hear from Sir Geoffrey Salmonds' paper that the Air Ministry proposed to construct special machines for the study of stability and control, and pointed out the advantage of having a machine in which space and weight could be used for instruments or for adding to the strength of the structure for the purpose of the experiments. The British arrangements for model testing, the speaker regarded as particulary complete and satisfactory, and he added that the cost of the work was small and the value immense. As an example of this he mentioned the fact that, in three instances, tests on model seaplanes had established the fact that the machines, if constructed, would have failed; the tests had thus been instrumental in avoiding considerable expense.

Our knowledge of the relationship between model tests and full-scale results, was such that the model test could be relied upon to give a first approximation. There were no discrepancies of large magnitude, but more full-scale testing was essential to progress. The real test of aircraft came with its use and its failures, and the one fact that stood out in connection with the latter was that serious troubles were usually due to trivial causes. The stoppage of the jet of a carburettor, for instance, might lead to serious consequences. To avoid this, one might look for a better type of carburettor, but the real cause of the trouble was the fact that the engine was so sensitive to changes of mixture, and inquiries as to suitable fuels for aero engines were therefore desirable. Professor Bairstow also referred to the fact that an officer who had taken a distinguished part in certain research work had been posted elsewhere, since he could only continue the research by sacrificing his career in the Air Force. The speaker pointed out that in another Government Department special arrangements were being made to provide careers in technical work, and he thought this might well be done in the Air Force. Finally he expressed appreciation of the increased facilities now provided to enable designers to see more of the performance of a machine before it was handed over to the authorities. The extra flying time allowed, viz., 3½ hours, although important, was not very great, and the speaker would welcome an extension.

The next speaker, Commander J. Bird, referred to Mr. Fairey's paper on seaplanes, remarking that there was no more controversial question than that of boats *versus* floats. Both, he said, had special uses, though it was sometimes maintained that one type was best for all purposes. As to the lack of full-scale tests under comparable conditions, the speaker said the Air Ministry had done much to rectify the deficiency, but the matter was very important and more could be done. He also mentioned that the Swedish Government had issued an invitation for machines to be sent to Gothenburg during the exhibition to be held there this summer, and expressed the hope that the Government would see its way to send a squadron, as, if this were done, it would enhance our aerial prestige, benefit the aircraft industry and afford an opportunity for obtaining data as to the behaviour of various types of machines under identical conditions. With reference to the comparison of the advantages and disadvantages of boat and float type seaplanes given in the paper, the speaker said the difficulty with regard to the high centre of thrust in the boat type had been overcome. He also thought the difficulty of beaching was not greater with the boat type than with the float type, and that the risk of total loss of the former was less, since the steps acted as double bottoms. The speaker did not agree with Mr. Fairey's suggestions as to improved methods of handling seaplanes, expressing the view that the proposals were too costly. Large seaplanes, the speaker thought, should be designed to remain afloat, going into docks or on to hards only when repairs were necessary. In conclusion, he pointed out that the engines supplied for use on seaplanes were identical with those used on aeroplanes, whereas for the former application more attention should be paid to such points as the position of the air intakes in order to prevent spray from getting into the carburettor.

Sir Richard Glazebrook, who followed, called particular attention to the necessity for fundamental research on which he said advance in aeronautics depended, and gave several examples of the class of work included in that category. The speaker also referred to the problem of the long-distance aeroplane mentioned by Sir Henry White Smith at the morning meeting. Sir Henry had pointed out that they did not know the best aeroplane to select for that class of work, but the speaker stated that the matter had been referred to the Aeronautical Research Committee who had made certain

recommendations to enable the necessary experimental work to be done. It was hoped in the end to save large sums of money as a result of the work. With regard to Commander Burney's paper, the speaker inquired whether the view was held that existing technical knowledge of airships was sufficient to go ahead with the scheme. He thought there were many problems to be solved in connection with the manufacture and operation of large airships, and expressed the hope that opportunities would be given for the experimental work which was being carried out a year or so ago by the staff of the National Physical Laboratory to be completed.

The next speaker, Major F. M. Green, questioned the statement in Air Vice-Marshal Salmond's paper that more than half the total cost of flying was due to the cost of the fuel, suggesting that the proportion given was too high. He also asked for an explanation of the statement in Commander Burney's paper that the life of an engine was proportional to the temperature of the exhaust gases. The speaker did not agree with the suggested use of gliders for obtaining experimental data, preferring the ordinary tests of models, and finally he asked Air Vice-Marshal Salmond if it were possible for the data obtained from experimental and research work to be made available for use by designers sooner than was the case with the present arrangements.

Commander Holden Richardson, on being invited to speak by the chairman, referred briefly to his experiences in his trans-Atlantic flight in the United States seaplane N.C. 3. He mentioned that the hull of this seaplane, as originally designed, would have been a complete failure, but said it was much improved as a result of experiments carried out in the tank at Washington. The speaker also referred to the importance of practical tests, remarking that it sometimes happened that designs which did not appear to promise well on paper gave excellent results in service.

Brigadier-General R. K. Bagnall-Wild, who spoke as the representative of the Institution of Automobile Engineers, called attention to the similarity between the problems of aviation and those of motor-car manufacture, and pleaded for a greater co-operation between the institutions devoted to aeronautics and the Institution of Automobile Engineers. The main contention of Professor B. Melville Jones, who continued the discussion, was that an upper limit should be fixed by some authority for the minimum flying speed (*i.e.*, the landing speed) of commercial aeroplanes in order to diminish the risks from forced landings on rough ground. He thought the minimum speed should be lower than 50 m.p.h. and not less than 30 m.p.h., remarking that this range would exclude most existing commercial machines. Another point he wished to refer to was the use of turn indicators which, he said, were still not fitted on commercial machines, although he regarded them as essential to the safety of machines flying in bad weather.

The next speaker, Sir Archibald Denny, referred to the relationship between model experiments and full-scale results, remarking that they had now had some 40 years' experience in the testing of ship models and could predict accurately from model to ship within a half per cent. Recently they had been dealing with model propellers and were gradually overcoming the difficulties, but results could now be guaranteed to within a few revolutions per minute and within a few per cent. of efficiency. The remainder of Sir Archibald's remarks had reference to the British Engineering Standards Association and its work. Mr. F. Handley Page agreed with Professor Melville Jones as to the need for low landing speeds, but mentioned, with regard to turn indicators, that three different types of these instruments had been tried on his firm's machines, and none had been found satisfactory. The difficulties, he said, lay in the instrument itself and not in its use. On Mr. Fairey's paper, the speaker remarked that some of the weights used in comparing flying boats and aeroplanes were inaccurate and said he thought this fact would materially affect the shape of the curve obtained.

The only other speaker in the discussion was Major-General Sir W. Sefton Brancker, who said he could not let Professor Melville Jones' remarks go unchallenged. One of the few things aviation gave, he said, was speed, and he deprecated the employment of low landing speeds since maximum speeds would also be reduced. The remedy for accidents arising from forced landings, he said, was the elimination of engine failures, and he added that no accident which had actually occurred could be attributed to a high landing speed. The speaker agreed with Mr. Handley Page as to turn indicators, adding that although one might say the use of these instruments was essential it was not possible to get one to work with the ordinary pilot.

No other member wishing to contribute to the discussion, the chairman called on Air Vice-Marshal Sir W. G. H. Salmond to reply to the points concerning his paper. In doing so Air Vice-Marshal Salmond first remarked that he had said a great deal in his paper as to what had been done, but had omitted to mention what had been left undone. He therefore pointed out that they had not succeeded in evolving a satisfactory gear for multi-engined machines, were not yet sure of the aerodynamic qualities of thick wings, had not succeeded in getting an all-metal machine which was economical to produce, and had not evolved a perfect turn indicator. Service and civil aviation, he continued, were intimately connected, and the utmost would be done by research to satisfy the needs of both. Safety and reliability were the burden of the message from the conference, and, in this connection, they were investigating the possibility of landing in confined spaces and of flying at speeds below the stalling speed; the solution of these problems would be of great assistance to civil aviation. Another problem to be tackled was that of landing in a fog, and attention should also be given to the production of a cheap commercial engine which, although not so light as those in existence would give good reliability and would not need overhauling at intervals of less than about 1,000 running hours. In answer to Major Green, the speaker thought that consideration must be given to glider experiments as they were not yet sure what the possibilities of these were. For the purpose of rendering information available to designers earlier than at present he would go into the question of issuing interim reports, but he thought such reports might be misleading. In answer to Commander Richardson and Commander Bird, the speaker said they had endeavoured to arrange comparative trials between boat-type and float-type seaplanes, but had been prevented from doing so by the fact that one of the machines had met with an accident; he hoped, however, to carry out some trials during the year. On the question of minimum speeds, raised by Professor Melville Jones, the speaker remarked that he had already explained what was being done to discover how to fly a machine at less than the stalling speed.

After a few remarks by Colonel Ogilvie, Mr. Fairey replied to the discussion on his paper, mentioning that he had expected more criticism of his comparisons between aeroplanes and seaplanes. In reply to Commander Bird, the speaker said it was quite true that the difficulty of the high thrust could be overcome, but only at the expense of a heavy load on the tail. Commander Bird's remarks as to the puncturing of the seaplane hulls or floats, the speaker said, applied equally to both types, and he added that bulkheads could not be used in the boat type forward of the main plane. After thanking Commander Richardson for his contribution to the discussion, the speaker referred to the comparison of the structural weights of aeroplanes and seaplanes, stating that the figures, when plotted, more nearly represented a cloud of dust than a curve, but he had endeavoured to arrive at a general average from the points. The figures used, he said, were mostly taken from official sources. It was not possible to alter the general shape of the curves by altering any individual points. For aeroplanes the proportion of structural weight to total weight must increase in the larger sizes, while in the flying boat, it did not increase so rapidly because the larger hulls could be made relatively lighter than the smaller ones. Geographical and other considerations, the speaker concluded, rendered a range of flight of about 2,500 miles desirable for many purposes, and the main point he wished to bring out was that the larger the aeroplane the smaller was its range of flight, but the opposite was the case with the seaplane.

At the conclusion of Mr. Fairey's remarks, the chairman stated that the business of the conference had been completed, and after a vote of thanks to the Mayor and Corporation of the City of London for the use of the Guildhall had been proposed and carried, the proceedings terminated.

NOTES ON NEW BOOKS.

It is only within comparatively recent years that the engineer has had occasion to interest himself in transcendental functions other than the circular. For long, moreover, his knowledge of these latter was pretty well confined to trigonometric work, but the advent of power distribution by the alternate current has led him to understand and appreciate expansions in Fourier's series. As time goes on, however, the need for some acquaintanceship with Bessel's functions is gradually making itself felt. Mr. Michell made use of these in developing the theory of his thrust block, and Bessel functions were also required in Professor Morley's discussion of the crippling of long struts subject to a transverse load. This article was published in our issue of January 24, 1919. One disability has, however, long been attached to the use of these functions, viz., the absence of adequate tables of their values. As a consequence, Mr. Michell had to calculate for himself most of the numbers needed in his research. Few, indeed, would make use of the trigonometric functions if it were necessary to calculate the value of a sine or tangent from first principles instead of abstracting it from a table. This drawback is being gradually removed, and we anticipate that the extensive tables of Bessel functions, both with real and with imaginary arguments which are appended to Professor G. N. Watson's treatise on "*Bessel Functions*" will do much towards popularising their use. The work in question is published by the Cambridge University Press at the price of 70*s.* net. Emphasis has been laid on the tables appended to this, because these are of special importance for those who require to make any practical use of the functions. The respondents are tabulated in most cases to seven significant figures. This appendix forms, however, but a small fraction of the text in which Professor Watson has developed the theory with exceptional lucidity.

Mr. Milo S. Ketchum's book on "*The Design of Steel Mill Buildings*" was first published in 1903 to provide a short course in the calculation of stresses in framed structures as applied to workshop buildings or mill buildings, as they are known in the United States. The book was originally written for the author's students in the University of Illinois, but found a wider public in the practising engineers, engaged in this class of work. The fourth edition is now issued by McGraw-Hill Book Company, Inc. (30*s.* net). The book has been largely re-written and enlarged to serve as a textbook in structural engineering and forms a ready work of reference. The elementary problems in structural design are dealt with very fully in Part I. The deflections of structures, stresses in statically indeterminate girders, trusses and frames, and the secondary stresses in trusses are discussed and explained in detail in Part II. General design and the application of the scientific principles given in the former parts to the design of mill buildings with examples of details of actual constructions are given in Part III. The problems are solved analytically and graphically, and the worked-out examples, covering most of the problems arising in actual practice, show clearly their application to design. The correct treatment of the external wind forces on a building as a whole and on its component parts still remains in an indefinite state. It is hoped that a careful analysis of the experimental work of recent years on the distribution of the wind forces on buildings and structures may lead to definite ruling on this subject and reconcile the apparent divergence between what is called theory and practice. Professor Ketchum's previous books on Structural Engineering contain a large amount of data and tables which have helped to co-ordinate and standardise the practice in the design of workshop buildings and have also helped materially to raise this class of work from the old "rule of thumb" practice to the scientific design of the present day with resulting economy of material.

Though the term "factory management" is now generally understood to be more or less synonymous with "scientific works management" and is interpreted in a wider sense than a decade or two ago, technical treatises still keep installation and management apart, if simply because each part is sufficiently big in itself. Yet the designer and the future manager of some new plant ought to be clear from the beginning, as to what space, power, general facilities and raw materials, &c., are at his disposal, what machinery will be required for his processes, and how the works and

buildings should be planned. All these questions will particularly confront the engineer who is asked to advise on the erection of small works in cases where economical considerations preclude the consultation of various experts. For these reasons probably Professor H. Dubbel, of Berlin, includes in his "*Taschenbuch für den Fabrikbetrieb*" (Berlin, Julius Springer; price 15*s.* 10*d.*, bound) chapters on steam boilers, gas producers, power engines, electric motors, power control, as well as on structural materials (metals, their treatment, and testing), welding, wood, lubricants and tools; and further, on organisation, building and equipment of works, ventilation, illumination, transmission, and handling of materials. The 883 pages of small, but clear type, illustrated by 933 text figures and 8 plates, are hardly sufficient for this vast scope, and it would have been better, in our opinion, if some of the sections had been left out altogether, or had been dismissed in a few words with due reference to other works. That would not have caused much difficulty, as the separate sections were compiled by different authors who give general references. The aim of completeness is praiseworthy; but we should rather have dispensed, if necessary, with the chapters on gas engines, producers, metal casting, &c.—though the remarks on casting defects to be guarded against, *e.g.*, are certainly useful—in order to have more about modern works ventilation and illumination. We acknowledge that the contributors to the volume have kept the general object of the book well in view.

Progress in the study of science and the application of the discoveries to the industrial and social life of the people has grown in magnitude so enormously during the last quarter-century that the author of a book on the subject is faced with the two alternatives of dealing inadequately with all the work or providing a reasonable account of the development in certain limited fields. Mr. Edward Cressy, the author of a work entitled "*Discoveries and Inventions of the Twentieth Century*," of which a second edition has recently been published by Messrs. George Routledge and Sons, Limited, of London, at 12*s.*6*d.* net, has chosen the second alternative. The first edition of this work was published in the first month of the European War, and the changes made in the period since then have been so great that little of the original matter appears in the second edition. The author has dealt with those inventions connected with mechanical and electrical power production, the increased speed of working in factories, refrigeration, soils and crops, traction and transport, wireless telegraphy and telephony, photography, radium and the modern theories of matter. This book gives some idea of the romance of modern progress and will prove quite fascinating to those who are not brought into intimate contact with the developments. Boys, especially, should early be told the story of the struggle towards perfection in the design of every device, the unending battle to save waste of natural resources and to improve the conditions of civilised life. Something of that story may be found in this volume. This book, although not free from faults, such as an inverted figure on page 73 and such spellings of thermit as thermite, on page 140, and verandah without the final letter on the plate facing page 328, is to be recommended to those who desire to know a little about those inventions on the use of which they unknowingly depend.

In the whole multifarious studies and sciences, trades and industries that have an important bearing on the design, manufacture, fitting-out and completing of the machinery aboard a steamship, especially if of relatively high speed and horse-power, as for instance with passenger carriers, the piping and pipe arrangement is by no means the least. Generally, it is ignored by technicians, because of the greater attractions of the study of the prime movers and generators, and the difference which can be made in any ship, by good, as compared with inefficient, pipe arrangement work, is not sufficiently nor generally appreciated outside marine engine drawing offices. "*Machinery and Pipe Arrangement on Ship Board*," by C. C. Pounder, A.M.I.Mech.E. (Published by Emmot and Co., Limited, Manchester; Price 17*s.* 6*d.*), deals specifically and fully with pipe arrangement work, and serves well towards preventing those commencing on such work from perpetuating past errors. This treatise is composed, to some extent, of a series of articles previously published by the author, who certainly has the necessary experience to deal with the subject. The text is confined to mercantile practice, and little reference is made to water tube boilers. Similarly the systems of piping peculiar to oil-engine vessels are not dealt with, although bilge and ballast ranges, &c., common to all vessels, are fully described. It is hoped that in future editions, new sections will be added and extensions made as suggested by experience, in order to keep in line with the ever-increasing developments in marine propulsion. The illustrations are good, although the scale to which some of the arrangements are reproduced is rather small.

Water power has formed the subject of an almost endless number of reports of recent years. While some of these have fallen upon barren and dry ground, other it is to be hoped will come ultimately to fruition. The prospects are small of making much use of water powers in these islands, but it is to the interest of our engineers and manufacturers that they should keep alive to the possibilities abroad, and especially to the considerable resources within the Empire. At a recent meeting in London, the United States was definitely named as the country from which hydro-electric plant was obtained. It is natural that countries such as that, and Norway and Sweden, should have developed a lead in a class of engineering in which our firms had greater difficulty in obtaining first-hand knowledge. That lead, however, has now been greatly diminished, if not eliminated, and the successful tenders by British firms show that now we will be in the running for this class of work. The reports of Water Power Committee of the Conjoint Board of Scientific Societies considered the whole resources within the British Empire. This report, with a few corrections introducing more recent figures, has now been issued in book form by Messrs. Constable and Co. (price 3*s.* 6*d.* net), under the title "*Water Power in the British Empire.*" The names of Sir Dugald Clerk, chairman, and Professor A. H. Gibson, secretary of the Committee, are attached to the volume, the former also contributing a preface.

In the Sedgwick Museum, Cambridge, there exists a collection of specimens illustrating the geology of building materials. This collection was mainly brought together by the late Dr. John Watson, who left manuscripts dealing with certain sections of the collection other than those upon which he had written books during his lifetime. One such set of notes has now been issued under the title "*Cements and Artificial Stones*" (W. Haffer and Sons, Limited, Cambridge; price 6*s.* net.). This has been prepared for publication by Dr. R. H. Rastall. It includes a preface, dated 1918, by Dr. Watson. The bulk of the volume is occupied with Portland cement, but plasters are also dealt with. The book does not go so much into the details of manufacturing processes as it does into the geology of the raw materials and the changes produced in the preparation of the finished product. The subjects are taken up in the systematic order of the museum, and each item is given the museum reference number so that the work forms a guide to the museum, or the collection of specimens arranged there may be regarded as illustrative of the subject dealt with so clearly and well in Dr. Watson's little work.

In 1919 the British rainfall organisation was transferred to Government control, and is now part of the department of the Air Ministry. The third annual report of the Superintendent of the Rainfall Organisation to the Director of the Meteorological Office, viz., the record of the "*British Rainfall of* 1921," has now been issued by H.M. Stationery Office, at the price of 12*s.* 6*d.* net, and constitutes the sixty-first annual volume dealing with the subject. The year 1921 was a remarkable one for the lengthy period of drought which approached in character that of the famous year 1887, and the records and comparisons made in the present volume will prove of more than usual interest. The work is carried out by over 5,000 observers in Great Britain and Ireland. The volume contains, in addition to the tabular data and usual records, special articles on the drought of 1921, the effect of rainfall on scarlet fever, and fluctuations of annual rainfall.

The young engineer who for the first time leaves this country to take up engineering work abroad is often called upon to face unexpected tasks. The training obtainable in an old country where trades unions and competition insist on specialisation, narrows a man's sphere down so that as the years pass the probability is that our youth will be less and less efficiently prepared for the all-round duties expected of them in the more remote lands. Even if they have had no actual experience, a knowledge of some common sense way to go about a task will be invaluable to them. Quite unexpectedly they may be called upon to carry on or take up, to save time, some bit of work to be done, quite foreign to their special branch of engineering. It is largely the pleasure which men have found in accomplishing work of this kind which has made Englishmen the pioneers they have proved themselves to be in the last two generations or so. As a convenient little help, full of a number of useful bits of rudimentary information, we can recommend to such young men Mr. J. R. McLeod's "*Practical Civil Engineering Simplified, for the Far East.*" (Cecil Palmer, London). This small volume, which would add practically nothing to one's kit, is priced 7*s.* Mr. McLeod is well qualified for the task he set himself, and has got together a very useful little volume likely to prove of service not only to the man slightly out of his element on emergency duty, but also to the junior civil engineer saddled, as often happens, with somewhat unexpected tasks and responsibilities.

So many people outside the world of engineering are interested in simple lathe work that there must be a large demand for a readable book which describes the construction of the machine and shows how the various operations are performed. For such readers, as well as for young mechanics and engineering apprentices, Messrs. Cassell and Co., Limited, have issued as one of their "Work" Handbooks, at 1*s.* 6*d.* net, a small book on "*Metal Turning Made Easy.*" This is a companion volume to another in the same series known as "*The Simple Lathe and Its Accessories*," and is mainly the work of Mr. Fred. Horner. It is a well-written and useful little book which should prove very acceptable to all young engineers, and to the larger field of amateur workers. The purpose of the book, to explain in detail the various simple operations of turning, boring, screw-cutting and other work with a lathe as well as the subsidiary processes in connection with them, has been achieved in a very satisfactory way.

BOOKS RECEIVED.

United States Geological Survey. Mineral Resources of the United States. I: 11. *Silver, Copper, Lead and Zinc in the Central States, Mines Report.* By J. P. DUNLOP and F. BEGEMAN. I: 13. *Antimony in* 1921. By FRANK C. SCHRODER. I: 14. *Arsenic, Bismuth, Selenium and Tellurium in* 1921. By V. C. HEIKES. I: 15. *Platinum and Allied Metals in* 1921. By JAMES M. HILL. II: 18. *Clay in* 1921. By J. MIDDLETON. II: 20. *Salt, Bromine and Calcium Chloride in* 1921. By K. W. COTTRELL. II: 21. *Barytes and Barium Products in* 1921. By G. W. STOSE. II: 22. *Asbestos in* 1921. By E. SAMPSON. II: 23. *Gems and Precious Stones in* 1921. By B. H. STODDARD. Washington: Government Printing Office.

A New Oil Engine. By A. F. Van AMSTEL. Amersfoort, Holland: A. F. Van Amstel. [Price 2*s.*]

The Radio Year Book, 1923. London: Sir Isaac Pitman and Sons, Limited. [Price 1*s.* 6*d.* net.]

United States Bureau of Mines. Twelfth Annual Report of the Director of the Bureau of Mines to the Secretary of the Interior for the Fiscal Year ended June 30, 1922 [Price 10 cents.] Technical Paper No. 265. *Mesothorium.* By HERMAN SCHLUNDT. [Price 10 cents.] Washington: Government Printing Office.

Reid's Handy Colliery Guide and Directory for the Counties of Northumberland, Durham, Yorkshire, Cumberland and Westmorland. Newcastle-on-Tyne: Andrew Reid and Co., Limited. [Price 3*s.* 6*d.* net.]

Gas Manufacture, Distribution and Use. Notes for Teachers. Second edition, revised. London: The British Commercial Gas Association.

Arithmetic for Engineers. By CHARLES B. CLAPHAM B.Sc. Third edition. London: Chapman and Hall Limited. [Price 7*s.* 6*d.* net.]

Mathematik. By H. E. TIMERDING. Berlin: Julius Springer. [Price 6*s.* 8*d.*]

The Elementary Principles of Lighting and Photometry. By JOHN W. T. WALSH, M.A., M.Sc., A.M.I.E.E., F.Inst.P. London: Methuen and Co., Limited. [Price 10*s.* 6*d.* net.]

Traité de Stéréotomie (*Charpente et Coupe des Pierres*). By JULES PILLET. Paris: Albert Blanchard. [Price 20 francs.]

Industrial Organisation, Developments and Prospects. By JOHN LEE, M.A., M.Com.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 5*s.* net.]

Drop-Forging and Drop-Stamping. By HENRY HAYES. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Forschungsarbeiten auf dem Gebiete des Ingenierwesens. Heft 258. *Verdrehungsversuche zur Klärung der Schubfestigkeit von Eisenbeton.* By OTTO GRAF and E. MORSCH. Berlin: Verlag des Vereines deutscher Ingenieure und Julius Springer.

The Work of the Royal Engineers in the European War, 1914–19. *Military Mining.* Chatham: Published by the Secretary, Institution of Royal Engineers. [Price 12*s.* 6*d.*]

The Institution of Aeronautical Engineers. Minutes of Proceedings. No. 3. *Aeroplane Design.* By H. P. FOLLAND, M.B.E. London: Offices of the Institution. [Price 2*s.* 6*d.*]

Gasmaschinen und Ölmaschinen. By ALFRED KIRSCHKE. Berlin and Leipzig: Walter de Gruyter and Co.

Der Kranbau. Berechnung und Konstruktion von Kranen aller Art. By Dr. Techn. R. DUB. Second edition. Wittenberg: A. Ziemsen. [Price 40 Swiss francs.]

Lehrbuch des Tiefbaues. Vol. I. By ESSELBORN. Leipzig: Wilhelm Engelmann. [Price 17·50 Swiss francs.]

Lehrbuch der Elektrotechnik. Vol. I. By ESSELBORN. Leipzig: Wilhelm Englemann. [Price 19·50 Swiss francs.]

Handbook of Construction. By HALBERT POWERS GILLETTE, M.Am.Soc.C.E. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 30*s.* net.]

Allgemeine Maschinenlehre. By HUGO FISCHER. Leipzig: Otto Spamer. [Price 6,300 marks, plus 200 per cent.

AERIAL LADDER FOR FIRE SERVICE.

CONSTRUCTED BY MESSRS. MERRYWEATHER AND SONS, ENGINEERS, GREENWICH.

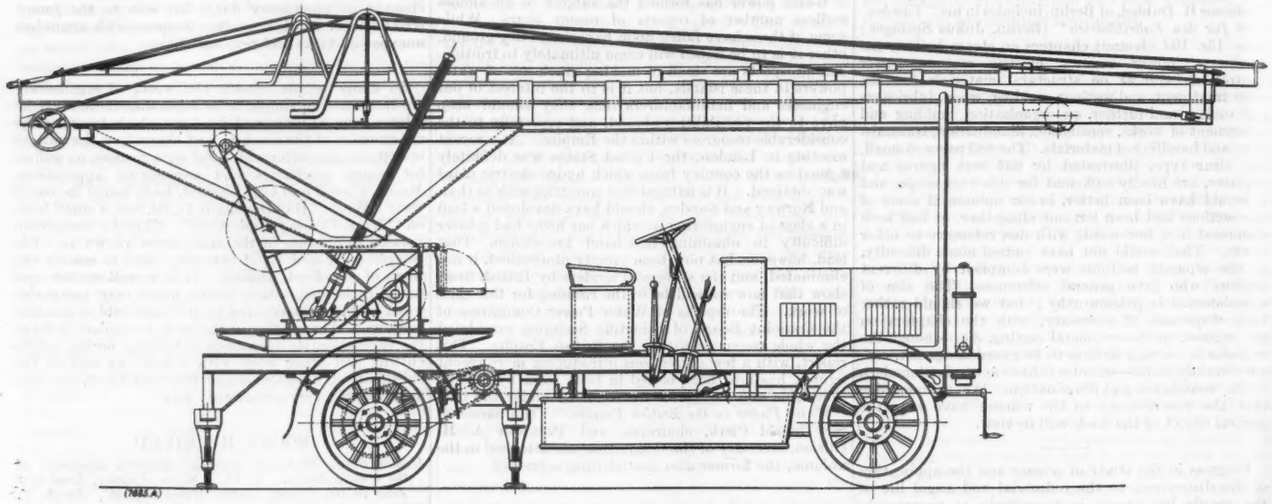


Fig. 1.

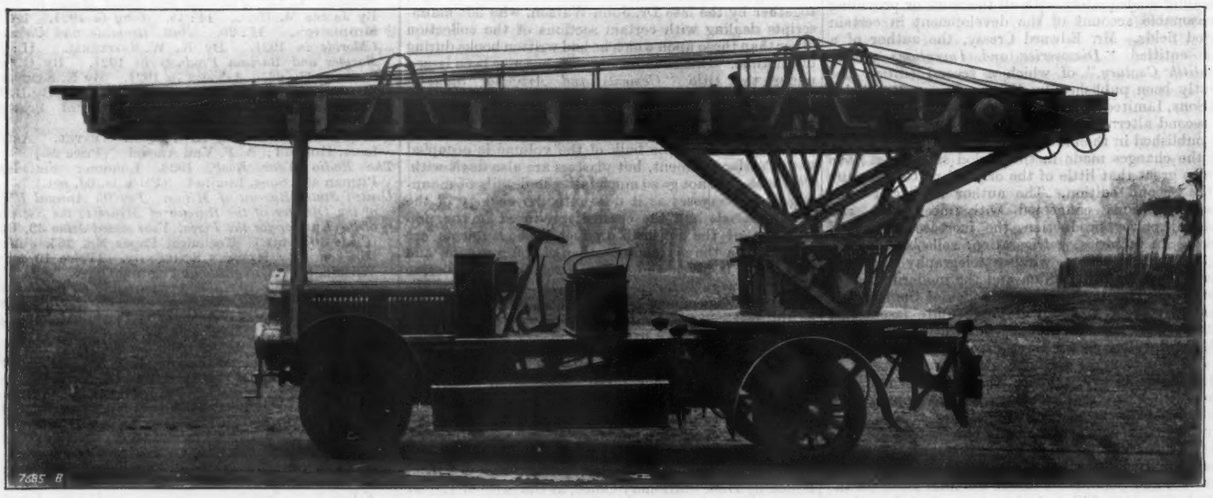


Fig. 2.

We illustrate in Figs. 1 to 6, on this and the opposite pages, the new self-supporting aerial ladder built by Messrs. Merryweather and Sons, Greenwich. As will be seen, the ladder is carried on an automobile chassis of special construction. The telescopic ladder marked A in the view, Fig. 3, is hinged to a revolving structure B fixed on the back part of the chassis C; the whole of the mechanism for adjusting the ladder in relation to the chassis, and for raising, it is driven by the motor which propels the automobile. The engine power is transmitted through an extension of the first-motion shaft in the gear-box to a vertical spindle in the centre structure B, around which the platform carrying the ladder revolves. The ladder operating gear is thrown into and out of connection with the propelling mechanism by a hand-lever operated from the driver's seat. The vertical spindle operates simultaneously, through worm and wheel gearing, two horizontal shafts D and E, controlled in either direction of revolution by metal-to-metal cone clutches operating in an oiltight casing F. One of the horizontal shafts has pivoting around it, at either end, a pair of screws G driven by bevel gearing H. These adjust the ladder at any angle through an arc of about 80 deg. These screws act as struts, and the thrust on them is well distributed over the framing of the chassis. The other horizontal shaft is geared to a drum carrying the steel wire rope for extending the ladder. The structure carrying the ladder is revolved around the vertical spindle by an extension from it carrying a separate pair of clutches for turning it in either direction.

The three operations of raising, extending and revolving in both directions are governed by three separate levers L, M and N (Fig. 3) worked by one man. Alternative hand-operated gears P are provided for each movement should occasion require their use. The ladder is of the telescopic type consisting of one main and three sliding sections, capable of extension to approximately 90 ft.; the ladder sections are trussed on their upper side with adjustable steel rods in tension, supported on steel struts. This form of ladder construction was found to be the most suitable type to employ in the case of the large number of self-supporting ladders supplied by Messrs. Merryweather during the war for airship building; the experience gained in their use has been found very valuable in the production of the new self-supporting aerial ladder we deal with in the present article.

Each sliding ladder section has at its lower end a pair of automatic pawls (see Figs. 4 and 5), operating on the rungs of the section next below it; the signal for the engagement of these is given by a gong. When the ladders are finally adjusted for use, the pawls are brought into operation, and no strain whatever is allowed to fall on the wire extending-ropes. When the ladder is fully extended, and a man stands at the highest point, there is no noticeable deflection.

The successful functioning of a piece of apparatus such as this, is naturally dependent upon the competency of the man in charge, but the most complete precautions have been taken to remove any possible cause of danger through mishandling. A well-illuminated scale in full sight of the operator shows exactly to what distance the ladder is extended, whilst a plumb indicator rod shows on a sector plate the safe extension of the ladder at any angle; the same plumb indicator also shows what degree of adjustment is required in a lateral direction to keep the ladder perfectly upright when on uneven ground. Lateral adjustment is controlled by a screwed spindle attached to the foot of the main ladder. In order, further, to prevent overwinding through carelessness of the operator, safety devices are brought automatically into operation immediately before the danger point is reached. These de-clutch either the raising or the extending mechanism.

An important feature in the construction of the chassis is the provision of four adjustable screwed struts revolving in hinged steel castings rigidly supported from the underside of the chassis frame. When brought into action these struts support the chassis directly from the ground, taking all the weight from the axle springs and rubber tyres; they also give the maximum area of base within the limits required for an automobile having a standard wheel track. The chassis itself is of the standard Merryweather Fire Service type, having a four-cylinder, 65-b.h.p. motor, and, as is usual with all appliances manufactured by the firm, having a chain-drive to the rear wheels.

At a demonstration recently witnessed by us at the makers' premises, the machine worked without a hitch of any kind; remarkable features are the extreme

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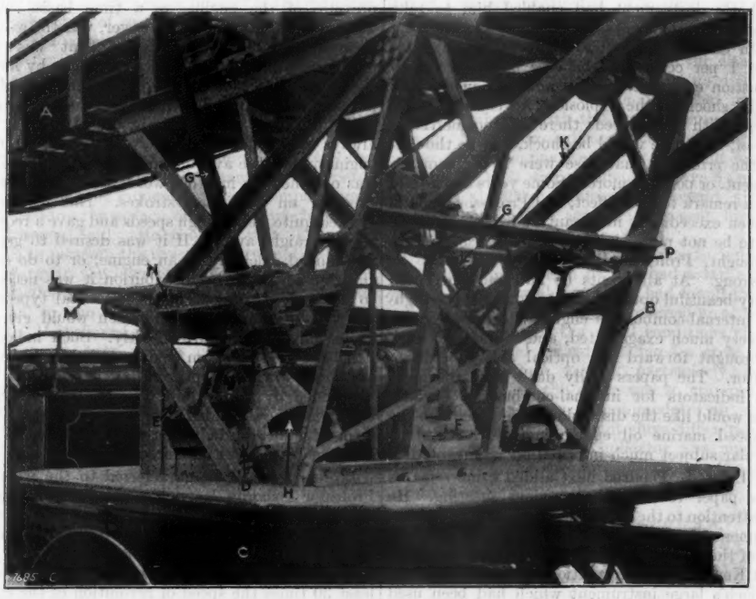


FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

simplicity of the mechanism and the accuracy with which the head of the ladder can be brought quickly into any desired position by the operator working the three control levers under his command.

Appliances of this type, the essential features of which are covered by patents, are already in commission in Edinburgh, Bristol, Portsmouth, Norwich, Durban and Hong Kong, where their performance under actual fire-service conditions is most satisfactory. In this connection it may be stated that, owing to the increasing height of the buildings which are being erected in large business and commercial areas in most countries, one of the chief problems to be faced is the possibility of directing a jet of water on the seat of the fire outbreak from a position external to the building. The appliance above described fulfils this purpose completely, in that it forms a point of vantage from which to direct a high-pressure jet of water at a height of 80 ft. or more from the ground, without any form of support other than that afforded by the weight and area of its base. The question of saving life also is of importance; considering, however, the by-laws now in force, governing the means of ready exit from high structures, the life-saving capacities of such an apparatus may be considered as being of a subsidiary nature.

Prior to the War most of the self-supporting ladders in use by the fire brigades of the United Kingdom were of continental make; it is greatly to be hoped that the enterprise of this old-established London firm will go far to convince British purchasing authorities that there is now no reason for placing orders for aerial ladders outside this country.

THE SUPER-POWER STATION: ERRATUM.—In our report of Sir Vincent Raven's remarks on this subject, which appeared on page 149 of our issue of February 2, the speaker is represented as having "thought that large stations with at least 15,000 kw. to 20,000 kw. capacity should be installed." This should read that he "thought that large stations with generators of at least 15,000 kw. to 20,000 kw. capacity should be installed." We much regret the omission, which was calculated to convey a wrong idea as to the purport of Sir Vincent's observations.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.—The Council of this Institute have decided to hold an International Congress on architectural education in London in the autumn of 1924. The congress will consist of special meetings for the purpose of considering the history, position and prospects of architectural education. The Institute state that the subject of the congress, important at all times to architects, is more than ever important at the present day, in view of the vital changes which are being introduced into British architectural education by the schools. It is hoped that a national and international exchange of ideas will lead to valuable future developments.

THE SIR JOHN CASS TECHNICAL INSTITUTE.—The annual prize distribution was held at this Institute on Wednesday, January 31, when the prizes and certificates were distributed by Sir Thomas Holland, F.R.S., Rector of the Imperial College of Science and Technology. Despite the restricted accommodation in the Science Departments, 31 students had been engaged in research work and five papers had been published, bringing the total number of original investigations issued from the Institute to 120. Twenty-five students had been successful at University of London examinations, six of whom had gained the B.Sc. degree with honours in chemistry. For the second year in succession a student of the Metallurgy Department had been awarded the first prize (silver medal) in the City and Guilds of London Institute Examination in non-ferrous metallurgy.

THE INSTITUTION OF MECHANICAL ENGINEERS.

As reported on page 95 of our issue of January 26 last, the ordinary general meeting, held on the 19th of that month was adjourned until Friday, the 9th inst., when the discussion on Indicators was resumed at the Institution Building, Storey's Gate. During the early part of the proceedings, the chair was occupied by the President, Dr. H. S. Hele-Shaw, F.R.S., and later by Sir John Dewrance, Vice-President.

The late Mr. Mark Robinson.

At the commencement of the meeting, Dr. Hele-Shaw referred to the death of Past Vice-President Mr. Mark H. Robinson, at whose funeral the Institution had been represented. Mr. Mark Robinson was elected a member of the Institution in 1894 and had served on the Council since 1901. His name would be enshrined in the Institution on the panel of the past vice-presidents now being prepared. One inestimable service rendered to the Institution by Mr. Robinson was the reorganisation of its finances, and the establishment of the amortisation fund whereby the Institution was steadily putting aside money against the time when it might be necessary to provide a new home.

Indicators.

The adjourned discussion on the four papers on Indicators read at the previous meeting was then resumed.

Dr. W. A. Scoble, referring to the four papers, thought it would not be out of place also to mention the article which appeared in Engineering on Friday, the 12th ult. He had lately been designing a pencil indicator, and those who tackled the problem would find that there were conflicting requirements. It was not easy to get a satisfactory result, something having to be sacrificed on one side to secure some desideratum on the other. He did not think British-made indicators took quite the place they should. The Crosby and Dobbie were the most commonly used. He thought the spherical piston introduced into the Crosby kept the design theoretically correct. The disadvantage of the system was important; the instrument did not possess much lateral stability. He had found it impossible to indicate an internal-combustion engine with a Crosby when using a rich mixture and advanced spark. When the barrelled piston was used the least little bit of grit wedged the piston and spoilt the job. He thought the advantage in the outside spring Crosby of getting the spring away from the gases was well worth the added weight of the rod. A great debt was due to Professor Hopkinson, whose indicator had inspired at least two later developments. Professor Burstall had produced an instrument which was a good engineering job. With high-speed instruments insufficient checking was done to ensure accuracy. Many instruments he thought were not too accurate. The ordinary pencil indicator worked well up to 300 r.p.m. It was a big jump from that to about 2,000 r.p.m. or six times the speed. The conditions in relation to speed were thus intensified 36 times, and the weights and amount of travel were insufficiently reduced in view of this, in high-speed instruments. In optical indicators there was even quite an appreciable movement. The Pointolite lamp system in the Burstall indicator did not give, he thought, sufficient intrinsic intensity of light and it could be improved upon. The Cambridge micro-indicator he thought had not been sufficiently checked. It was very ingenious, but the stylus introduced pencil friction in an intensified degree, and there was, he thought, a considerable amount of lag in the record obtained.

Captain H. Riall Sankey remarked that at the previous meeting, Dr. Hele-Shaw had said that one of the reasons for the symposium on indicators was the possibility that it might be of assistance to the Marine Oil Engine Trials Committee. There were other objects, but that was one of the chief. He much hoped that the discussion would turn on taking indicator diagrams for heavy oil and marine engines running at comparatively slow speeds. The old steam engines running at very few revolutions gave a very stately diagram. There was then almost a certainty that that diagram gave the true indicated power of the engine; the errors hardly exceeded half of 1 per cent. There was no shock, no inertia effect. With the high-speed steam engine, there was still no shock, but there was inertia effect in the indicator. Willans stated that the Crosby instrument had enabled him to take indicator diagrams at 400 r.p.m.; even then, Captain Sankey, believed, the inaccuracy did not exceed 1 per cent. In the case of the internal-combustion engine, there was not only inertia but also the shock of the explosion, a very disturbing factor. With slow speeds there was no inertia to speak of, but there would be shock, and he thought that the errors in that case were 2 per cent. to 3 per cent. or possibly more. Some years ago he had made a remark to that effect, and Professor Burstall had been exceedingly indignant at it, believing the error to be not more than 1 per cent. Since then, he thought, Professor Burstall had seen that he was wrong. At all events he had since invented his very beautiful optical indicator. With the high-speed internal-combustion engine, shock and inertia were very much exaggerated, and it was that that had brought forward the optical and the micro-indicator. The papers really dealt with the high-speed indicators for internal-combustion engines, but he would like the discussion to embrace also the slow-speed marine oil engine indicator. On that particular subject much information was wanted.

Mr. L. St. L. Pendred next added some remarks to his paper read at the previous meeting. He drew attention to the fact that a number of additional instruments had been added to those exhibited, some of them kindly loaned by the Science Museum, South Kensington. He particularly drew attention to Gooch's large instrument which had been used on locomotives, and contrasted greatly with the Cambridge instrument. The Wayne indicator drawing the diagrams on curved paper was also shown. He had hoped also to show the new Dobbie-McInnes indicator using a spring in tension, but it was not quite ready. He also referred to the Watson-Dalby instrument, which he showed through the kindness of Mr. Cussens, and described the various parts both by means of the instrument itself and with the assistance of lantern slides. Mr. Pendred also showed a slide of one of Mr. Collins' card discs held between pieces of glass, showing the little diagrams very clearly. A diagram from the R.A.E. indicator was next reproduced on the screen and the manner in which it was obtained further explained. In the Watson-Dalby instrument the mirror was a platinised metal surface, but Prof. Burstall had adopted a small glass mirror. The latter had the disadvantage of being very expensive, while the platinised surface he thought had also the advantage that it excluded all ghost effect.

Mr. W. J. Still, who followed, exhibited a series of lantern slides of diagrams taken in the course of research work on his engine system, with a view to making determinations of friction. The cards were taken under the supervision of Professor C. V. Boys, and the Hopkinson optical indicator had been used. At the speeds of about 800 r.p.m. about 12 cycles had to be indicated to make a legible record. The great defect of these optical instruments was that they could write faster than they could record. He thought the indicator error was probably well within 2½ per cent.

Mr. W. Stern, of the Air Ministry Laboratory, said that the chief points in the optical indicator were concerned with the diaphragms, and method of clamping. These he wished to discuss in a written contribution. He desired to mention, however, an instrument designed at the Air Ministry Laboratory by the Superintendent, Major Wimperis, because it introduced the very inertia which was the bugbear of the ordinary instrument. The Wimperis indicator depended upon having a large amount of inertia, and the instrument would show the mean effective pressure of the engine straight away on a dial. In principle the instrument consisted of a pivotted bar, against one end of which was pressed the rod of a small piston in a cylinder connected with the engine cylinder. On the other side of the bar, pressure was applied by an adjustable spring keeping the bar and piston rod in contact. A heavy disc was applied to the spindle on which the bar was mounted. If the disc was made relatively heavy and the spring light so that the period of the instrument was low, the pointer would not swing following all the fluctuations of pressure in the cylinder, but would take up a definite mean position. This gave the average pressure of the engine on a time basis. What was more often wanted, however, was the average pressure on the stroke basis. That was very ingeniously obtained by Major Wimperis by having the bar or lever slotted, the point where the piston pressure was applied being made to reciprocate along the bar. If the reciprocating motion was always proportional to the velocity of the main engine piston the average space value of the torque was obtained, or in other words the mean effective pressure on the four strokes. The instrument worked quite well at high speeds and gave a required result straight away. If it was desired to get the mechanical efficiency of an engine, or to do something to improve the distribution it was necessary to have an instrument of the electrical type or of the type he had described which would give the mean effective pressure directly. Such indicators had been used in steam engine work for some time, and he was rather surprised that they had not been mentioned by the authors or speakers. Mr. Stern concluded by sketching diagrammatically one such form of indicator in which the rotation of a disc between bevels was measured.

Professor E. M. Lamb referred to the paper by Professor Osborne Reynolds and Dr. Brightmore, read before the Institution of Civil Engineers in 1885, and commented upon the question of inertia. The restriction that the free frequency of the indicator piston and pencil mechanism should be at least 30 times the speed of revolution of the engine was more serious than at first appeared, for the natural frequency for a given mass of piston was proportional to the square root of the spring-elasticity, the quantity e in Reynolds' paper. To be free from serious errors due to piston and pencil mechanism inertia it was necessary to put in so stiff a spring that the height of the diagram was reduced inversely as the square of the number of revolutions of the engine. Hence the possibility of securing accurate results at anything more than 300 r.p.m. was rather remote. Reynolds considered the error of the spring due to temperature might amount to about 3 per cent. at 100 deg C. if the spring were calibrated cold. For this reason the outside spring instrument was an improvement. A third point was pencil friction. Reynolds always used a soft lead pencil and a hard smooth paper, but the points commonly used with the metallic paper supplied had a hardness five to six times as great as an H.B. pencil. The modern Crosby instrument embodied many of the requisite features of a good indicator. The spherical piston was worth notice. After five or six hours run it was found that the lower part of the piston was slightly blackened, but there was no indication of blow. It was admirably free. For gas engine work at 500 r.p.m. to 600 r.p.m. why should not an external spring type of indicator be used with a stiff spring to give a card ¼ in. high, at the same time reducing the drum movement to about 1 in., using a steel scriber on a celluloid film. That would immensely reduce inertia errors. In optical indicators if there was the slightest movement on its foundation the record showed it. After pointing out some defects of the Hopkinson instrument, Professor Lamb said the cost of optical indicator diagrams was about 3*d*. each, exceeding the cost of fuel to run the engine. He suggested making the piston of the optical indicator as small as possible (2 mm. in diameter). Professor Lamb then proceeded to comment upon the Cambridge and R.A.E. instruments and concluded by referring to Prince Galitzin's new system of seismograph and the possible application of the principles employed to the indicating of engines as suggested in a note by Prince Galitzin.

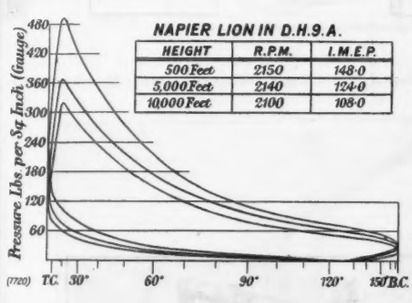
Professor C. E. Inglis said he thought the Cambridge indicator might be classified as a general utility indicator. It was a very adaptable and ready instrument, but it was by no means rough. It was an instrument of precision, and he believed its accuracy left little or nothing to be desired. There were two points connected with the indicator

which seemed to him to be of outstanding interest, the first being the spherical piston, which had been mentioned by several previous speakers. That freed the indicator from all moving joints, a most necessary condition in a high speed small movement indicator. But the point of outstanding interest in the indicator was the method of recording on a celluloid film by means of a stylus. In that respect he honestly thought Mr. Collins had made a very great discovery. The secret of the method was that the stylus had a slightly blunted point, and instead of excavating the surface as it passed over it, it merely made a slight furrow. The material was thrown up on either side in the form of minute banks. The amount of friction involved seemed to be microscopic. Under the influence of those comparatively small pressures the surface, he believed, was behaving as a viscous fluid. He thought that if it were possible to measure the resistance it would be found to conform to the laws of fluid friction and not of solid friction, and that at small velocities the force required to move the stylus would practically vanish. He believed that that method of recording was likely to have a very great future. It had been used in other directions. He had had some experience of an instrument evolved by Mr. Collins for taking records of strains on bridges caused by the passage of moving loads. A record was available immediately after the train had passed over. He thought a very valuable test in connection with every indicator was a hysteresis test. The indicator ought to be tested with a gradually increasing pressure, and the pressure should then be decreased and the two graphs compared. Very few indicators came out of that test quite unscathed, showing no loop. He would like to know whether there were available any figures relating to that point in connection with the Cambridge instrument.

Mr. Alfred Crossley exhibited some lantern slides showing the latest types of Crosby instruments. In the Crosby New No. 2 the spring has now been put on the outside of the instrument, and it became a tension spring instead of a spring in compression. The errors of lateral flexure therefore disappeared because the forces were central. Mr. Pendred had suggested a ball at each end of the spring. In the new Crosby the pencil mechanism was connected separately with the piston by a rod which had at its lower end a ball fitting into a socket in the centre of the piston. At the upper end of the piston rod a ball joint was also formed on the spring itself in the well known Crosby manner. There was a lot of loose thinking connected with the use of indicators. They were often selected without due regard to the work they had to do. The load upon the piston of an indicator should not exceed 125 lb., total. That was often lost sight of. People tried to indicate Diesel and other high-pressure engines with pistons half a square inch in area. The correct piston area for a Diesel engine should be about $\frac{1}{8}$ sq. in., if, as undoubtedly would be the case, pressures of 750 lb. or 800 lb. per square inch were to be dealt with. If the correct size of piston were ordered, a lot of the fault laid against the pencil indicator would disappear. Instead of using proper cord, people often thought anything else would do just as well, and then blamed the indicator for the results.

Flying Officer C. J. Simms, D.F.C. (Air Ministry Laboratory) said that those who were used to steam-engine diagrams were used to a constant repetition of the diagrams. In the case of a high speed petrol engine, however, nothing like that repetition was obtained. The maximum explosion pressures and everything else varied. The three forms of indicators described had different uses. It was necessary to have an indicator for the laboratory to take one diagram, and one only; on the other hand, an instrument suitable for the works would be required to take a mean diagram only. The optical indicator at first gave a mean of many explosions, but it could, if a sufficiently powerful point of light and sufficiently fast plate were used, give a single diagram. One of its disadvantages was its bulkiness. For single cylinder development work it was probably ideal, because with it it was possible to see what occurred when anything was varied on the engine. With any other instrument it was impossible to see what was happening. The R.A.E. type of indicator was useful for the works test bed where the mean was merely wanted. The micro-indicator was essentially of the single diagram type. In the Maihak micro-indicator the piston used was quite small, being of the order of 0·5 of a square centimetre. The spring was of the tension type, double wound helical, while the coupling was direct. Reference had been made to the fact that the thickness of the line on the glass plate was quite appreciable, and that was no doubt the case, the figure being 0·01 mm. That was fine enough compared with the area measured. In his opinion the micro-indicator should be of great use in marine engine work. It was built for high speed work, as it was considered it gave 5 per cent. accuracy at 800 revolutions, it would give an accuracy within 1 per cent. or $\frac{1}{2}$ per cent. in marine engine work.

Mr. E. T. Vincent, with reference to indicating marine oil engines, said he had had a fair amount of experience of such work and had found that the mechanical type of indicator possessed great advantages for it. Under the usual conditions of ships at sea the optical indicator suffered a great disadvantage. In many vessels, particularly in the submarine service, the space was so cramped that it was impossible to accommodate an optical indicator. Even in merchant ships difficulties were experienced. The pencil indicator was much the easier to use under such circumstances. If a pencil



indicator were operated in an intelligent manner, he thought its accuracy for speeds up to 400 r.p.m. and 500 r.p.m. was almost equal to that of the optical indicator. He had compared several diagrams taken simultaneously with an optical indicator and a pencil indicator, and found the cards practically coincided. At the explosion end, where the biggest difference occured, the variation was not more than 10 lb., which was not much in a matter of 600 lb. In research work, the optical indicator would probably be given the preference. To obtain accurate diagrams it was necessary that the piston should not be left in the cylinder, as it should not be allowed to get very hot. Only one diagram should be taken at a time, and the piston should then be taken out and cleaned. One great difficulty in indicating engines up to 400 revolutions was the reducing mechanism for the piston movement. That was difficult to arrange for in high speed marine engines where the space available was rather limited. He thought the type of gear mentioned in a paper read by Engineer-Commander Hawkes before the Institution of Naval Architects in 1920 had advantages. In this the direct drive from the piston was obtained by means of a steel tape similar to that fitted to the Collins indicator. The tape in question would easily go round a pulley of about 2 in. diameter without breaking. It saved the use of a bell crank lever such as was employed in Professor Burstall's method.

Mr. A. E. L. Chorlton said he wished to discuss some of the diagrams of indicators that were shown at the previous meeting. Most of the diagrams showed a certain amount of vibration. His object was to inquire whether that point could not be studied to a greater extent. He had a case several years ago in which the diagrams were rather remarkable, and the point to which he directed attention had never been properly cleared up. The curious point in these cards was the vibration shown on the compression line. No attempt to damp out that vibration had been successful, and he would like to know more about how it was produced. The subject was possibly rather a big one and that was why he introduced it to the notice of the meeting. The vibration, if it was vibration, could actually be traced down to the vibration set up by the exhaust. The engine in question was a two-cycle engine, and the test was made with a Crosby indicator. He would like to know if there was any relation between the initial vibration set up when the exhaust ports or valves closed and the vibration on the compression line.

Mr. W. Sydney Smith, remarked that he thought it would interest the members to know that the forecast he gave a fortnight ago that, in the very near future, indicator diagrams would be taken in the air, had been fulfilled on the previous Saturday, February 3. The indicator had been fitted in a D.H. 9 aeroplane, driven by a 400-h.p. Napier-Lion engine, and diagrams were taken at 500 ft., 5,000 ft. and 10,000 ft. by Mr. Wood.

Mr. H. Wood, who followed, showed slides of photographs illustrating the indicator fitted in the aeroplane on which the diagrams were taken. A slide was also shown reproducing two actual diagrams, one taken at 5,000 ft. and the other at 10,000 ft. Another card showed these diagrams replotted to the usual P.V. form, together with one taken at 500 ft. These are reproduced in the accompanying figure. The decrease in mean effective pressure due to reduced density on rising in the air was clearly shown, the figures being, at 500 ft., 148; at 5,000 ft., 124; and at 10,000 ft., 108.

Mr. W. G. Collins, in reply, said the piston friction had been proved in his instrument to be exceedingly small. He thought he might safely say that the total piston friction and stylus friction was well within 1 per cent. A number of hysteresis tests had been made with very slightly changing pressures up and down, and there again the differences were well within 1 per cent. With regard to the small vibrations shown in one of the diagrams compared with the Crosby he had not yet had an opportunity to go into that point, but in any case, the vibrations were of a very modest character and scarcely affected the results.

The Chairman (Sir John Dewrance) then brought the meeting to a close.

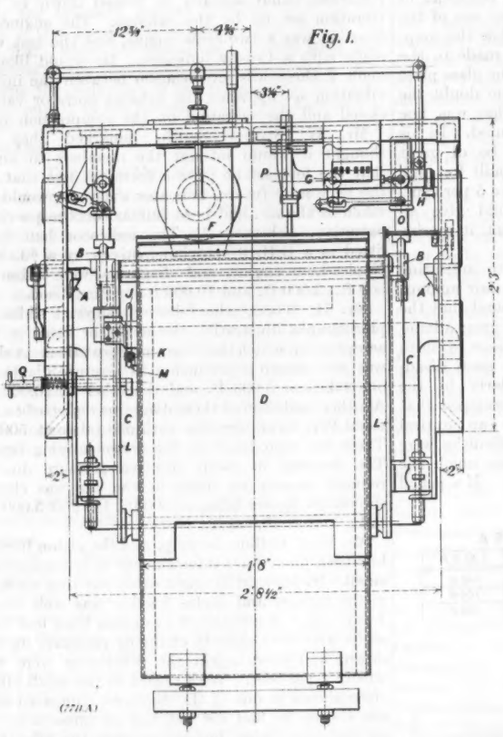
THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

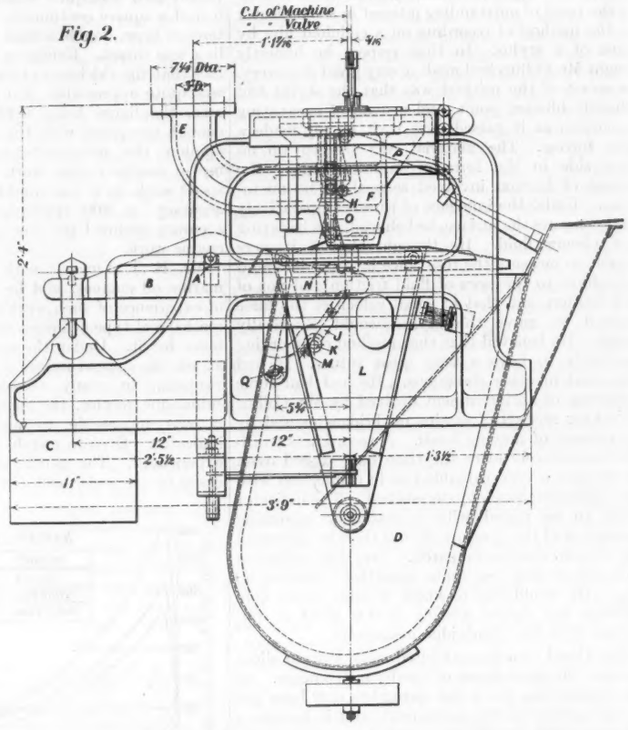
THE Birmingham Section of the British Industries Fair, which opens on Monday next, February 19, will be held, as in previous years, in the old Aerodrome buildings at Castle Bromwich. The three large buildings, now connected together by a covered passage way, provide probably as good accommodation for an exhibition as could be found in the Kingdom, as they impose no restriction upon a systematic arrangement of the stands, thus enabling the display of the wares of the exhibitors to the best advantage. We have had occasion, before, to praise the energy and organising ability displayed by the Birmingham municipality and Chamber of Commerce in connection with these Fairs, and this year as formerly, the Committee has used every endeavour to make the Fair a great advertisement of the machinery and metal industries of Great Britain and the Dominions. To facilitate business ordinary sight-seers are excluded, admission being confined to representatives of business houses. Thousands of invitations have been sent to foreign buyers to visit the Fair, and their inspection is facilitated by the extraordinarily complete catalogue, indexed in three languages, and showing at a glance every stand on which any particular kind of goods is to be found. It is greatly to be hoped that the attendance of buyers will be worthy of the opportunities afforded them, and that the result of the Fair will be to stimulate the revival of trade which we believe has now definitely set in.

In this connection we may mention that the exhibition authorities have received notification of intending visitors from no less than thirty-five separate countries. Large numbers of buyers are coming from the United States, Canada, Holland and Scandinavia, while Australasia, India, the Far East, Africa and South America will be well represented. For the convenience of visitors the Birmingham Fair will be linked to the simultaneously

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

MESSRS. W. AND T. AVERY, LIMITED, ENGINEERS, BIRMINGHAM.





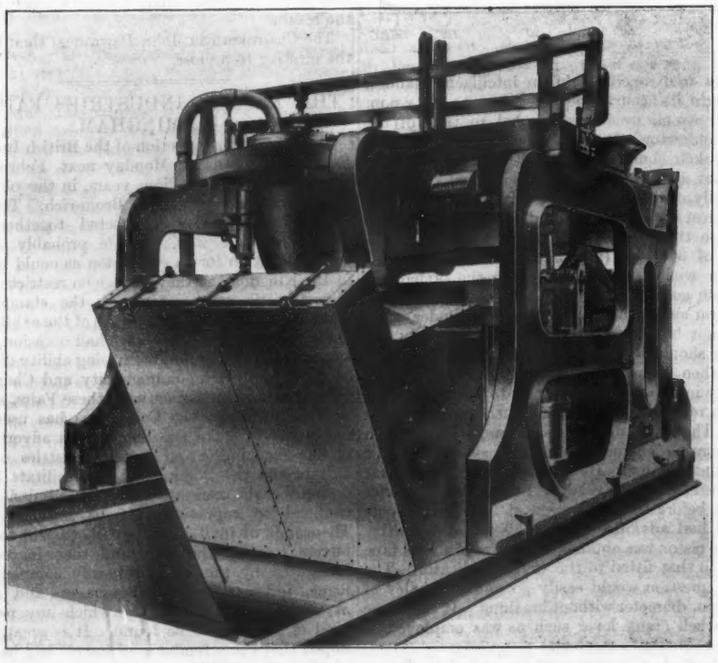


Fig. 3.

Figs. 1, 2 and 3. Automatic Liquid-Weighing Machine.

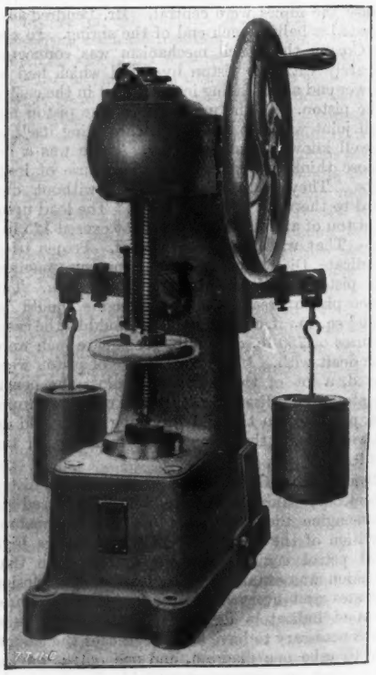


Fig. 4. Brinell Hardness Testing Machine.

held London Fair by a special service of Daimler aeroplanes, and air services will be maintained by the same company to Manchester, Paris and Amsterdam. As the Birmingham Fair is situated on the old aerodrome grounds, there are excellent landing facilities within a few minutes' walk of the doors of the exhibition buildings. The aeroplanes will be fitted with apparatus for wireless telephony, so that they will be able to communicate with the Fair while in flight. For the convenience of visitors who prefer to travel by rail a frequent service of trains has been arranged to Castle Bromwich station which adjoins the Fair grounds.

The bulk of the exhibits at Birmingham reflect the nature of the industries upon which the prosperity of the City and neighbourhood so largely depends. Brass and copper in the form of rods, sheets and tubes are much in evidence, while the multifarious forms of domestic hardware, woven wire goods, lamps, hearth furniture, cooking utensils, &c., occupy a good proportion of the stands. In many of the household appliances which lend themselves to decorative treatment a high artistic standard is now obtained, which goes to show that

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

THE TANGENT TOOL ENGINEERING COMPANY, LIMITED, ENGINEERS, KEYNSHAM, SOMERSET.

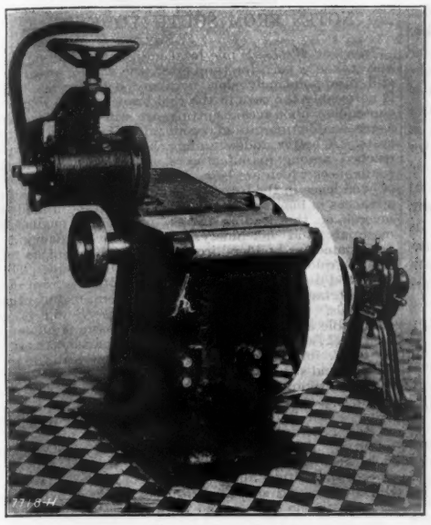
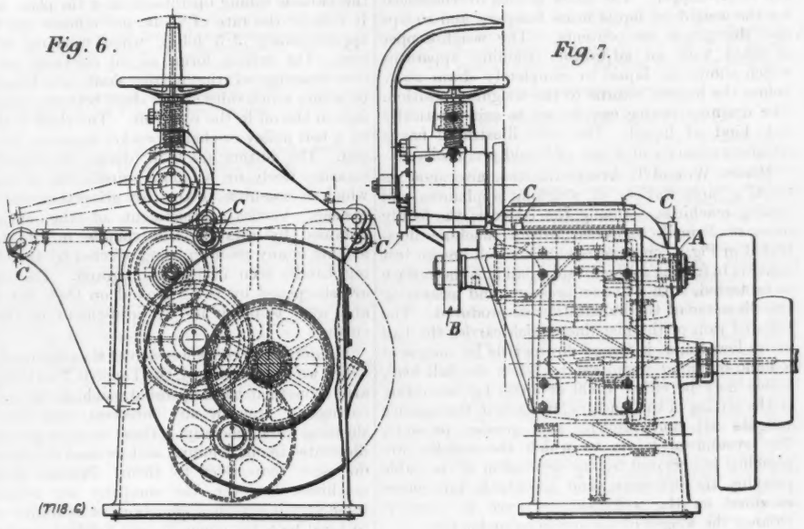


FIG. 5.



FIGS. 5, 6 AND 7. ROTARY SHEARING MACHINE FOR ½-IN. PLATES.

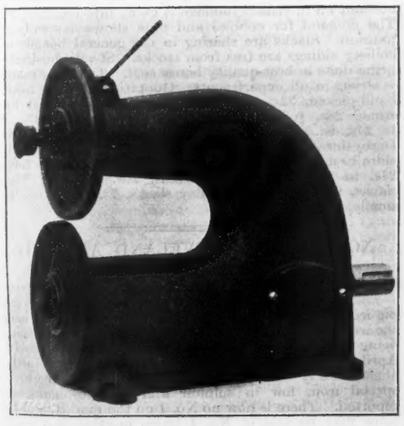


FIG. 8. ROTARY SHEARING MACHINE FOR ⅛-IN. PLATE.

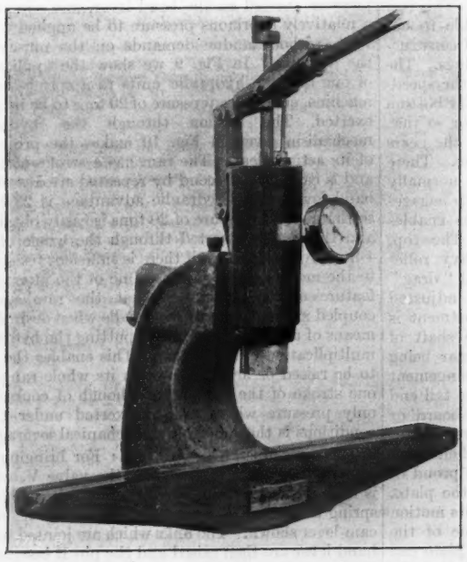
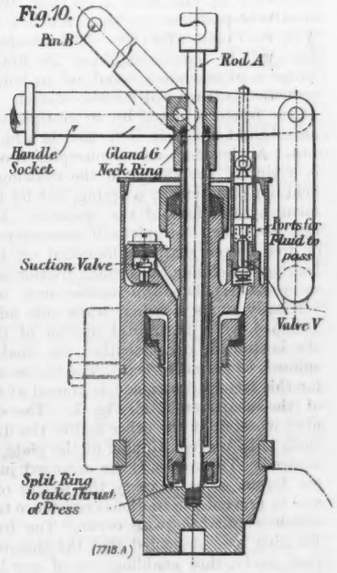


FIG. 9.



FIGS. 9 AND 10. HYDRAULIC TESTING MACHINE FOR SPRINGS.

beauty in design is not incompatible with modern methods of manufacture, nor is it unattainable by British craftsmen. Articles such as these, however, are not generally of professional interest to our readers, and we may turn at once to exhibits of a more mechanical nature, reserving further comment on the exhibition as a whole until after the official opening.

There are cases when a knowledge of the actual weight of water or other liquid which passes a given point is preferable to any measurement of its volume. Such cases are best met by the use of automatic scales which discharge the liquid in quantities, each of predetermined weight, and record the number of weighings made. The type of scale exhibited for this purpose by Messrs. W. and T. Avery, Limited, of Soho Works, Birmingham, is illustrated in Fig. 1 to 3, on page 204. Referring to these illustrations, it will be seen that the weighing apparatus is supported between a pair of substantial cast-iron frames, which carry supports at A for the knife-edges of the weigh-beams B. These beams carry at one end the weightbox C and at the other the hopper D in which the liquid is weighed. When the hopper is empty it is exactly balanced by the empty weightbox. The latter is constructed to hold the required quantity of standard weights, and is formed with a sloping top to prevent the accumulation of dust.

The liquid to be measured enters by the branch E and is regulated by the valve F. This valve is controlled by the main lever which is pivotted at G, and fitted with a steel roller which during the dribbling period of the scale rests upon the trigger H. The tipping hopper D is kept from discharging during the weighing operation by means of the lever J and roller K fixed to the hopper carrier L, which rests against the roller M attached to the weigh-hopper D. N is an ordinary register or counting apparatus worked from the lever pivotted at G which records the number of times the machine operates.

The action of the machine is as follows. When the required quantity of weights are placed in the weight-box C, the end of the beam B is depressed until the projections on the box C rest on the side-frames. The other end of the beam rises, and by means of the projection N catching under the pendant O, raises the end of the main lever pivotted at G, thereby opening the valve F. The liquid flows into the weigh-hopper D until its weight depresses the beam B. The pendant O being no longer supported by the beam, descends and partly closes the valve until the roller rests on the trigger H. The only liquid now entering the weight hopper is that which flows through the diminished aperture of the valve F. This dribble continues until the weight in the hopper is equal to the weights in the box C, when the beam finally descends and draws out the trigger H from beneath the roller on the main lever G, thereby completely closing the valve. The valve is prevented from re-opening until the hopper has discharged its contents and returned to the weighing position by the roller in the locking lever P

coming under a roller at the inner end of the main lever.

As the beam finally descends to cut off the supply from the valve F, the discharge lever J fitted on the hopper carrier L strikes the disc at the end of the discharge arm Q, and so is lifted clear of the roller M on the weigh-hopper. The latter is then overbalanced by the weight of liquid in its forepart, and so tips and discharges its contents. The weigh-hopper is fitted with an adjustable draining apparatus which allows the liquid to completely drain away before the hopper returns to the weighing position. The draining device can be set to suit practically any kind of liquid. The scale illustrated has a weighing capacity of 3 cwt. of liquid per discharge.

Messrs. W. and T. Avery, Limited, also show as usual a large variety of weighing appliances and testing machines. Among the latter is the handy form of Brinell hardness testing machine illustrated in Fig. 4, on page 204. This well-known test consists in forcing a 10 mm. steel ball into the surface to be tested, with a known pressure, and measuring the diameter of the indentation so produced. The screwed ram of the machine, which carries the ball at its lower end, is forced downwards by means of a hand-operated worm gear. When the full load, which may be either 1,500 or 3,000 kg. according to the setting of the machine, is reached, the balance weights lift and prevent any greater pressure. The system of levers to which the weights are attached is operated by the depression of the table carrying the specimen, and adjustable tare-pieces mounted on the weight-levers serve to counterbalance the weight of the specimen under test.

A new type of rotary shearing machine constructed by the Tangent Tool Engineering Company, Limited, of Keynsham, Somersetshire, is illustrated in Figs. 5 to 7, on page 205. This is a relatively powerful machine, which is able to cut ½ in. steel plate with ease. The details of construction will be understood from the drawings. The frame is of cast steel, cored out to hold the speed-reduction gearing, which is also of steel. The bottom of the frame is closed by an oil-tight door so that an oil-tight reservoir is formed in which the gears run. All bushings are of phosphor-bronze. There is a clutch, not shown in the drawings, normally held out of action by a spring, but let into engagement by the foot of the operator. This enables him to "inch" a plate if necessary. The top, or free cutter shaft, is mounted on heavy roller bearings to eliminate as much friction and "drag" as possible. The top cutter can be adjusted vertically in its housing, while side adjustment is obtained by a horizontal motion of the shaft of the bottom or driven cutter, the final gear being splined, to permit of this. The thrust arrangement for this latter adjustment is housed at the tail end of the shaft, at A in Fig. 7. The outboard or idler wheel B at the other end of the driven cutter shaft is to prevent tipping of the plate when being sheared. The rollers C are arranged just proud of the frame, so as to carry the weight of the plate, and to prevent the frictional resistance to its motion which would otherwise occur. The frame of the machine is so staggered that the sheared plate can pass freely, thus enabling cuts of any length to be made. Moreover, the design is such that any partly sheared plate can be readily withdrawn, as there is no obstruction to foul the deflected parts. The machine illustrated has been tested up to a cutting speed of 23 ft. per minute on ½ in. plates, the power then absorbed being about 23 b.h.p. Although its behaviour was entirely satisfactory under these conditions, the cutting speed recommended is 10 ft. per minute, as at this speed the work is under perfect control, the operator being able to start on and cut to a line, and to stop exactly at any desired point. At this speed the power required for ½ in. plates is 15 b.h.p. The weight of the machine is only 17 cwt., and the height of the plate being sheared is 30 in. It may be mentioned that the function of the curved arm shown in its vertical position in the drawings is to act as a guide or gauge for the operator when making a straight cut. The end of it lies exactly in the plane of the cutters so that when it is swung down on to the work, as shown dotted in Fig. 6, it will lie on the line along which the cutters will shear the plate.

The Tangent Tool Company also exhibit the very simple rotary shearing machine, illustrated in Fig. 8, page 205. This has a 9-in. gap frame, made of a single casting, and will cut mild steel plate up to ⅛-in. thick. The machine was originally devised to trim the ends of "packs" between the various rolling operations in a tin plate works. It cuts at the rate of 75 ft. per minute and takes approximately 3·5 b.h.p. when working at this rate. The casting forms an oil reservoir, and the two bearings of the cutter shaft are lubricated by a ring which rides on the shaft between them and dips in the oil in the reservoir. The shaft is driven by a belt pulley or chain sprocket keyed to its outer end. The cutters are 9 in. diam., the upper one rotating freely on a short spindle the journal of which is eccentric to the part gripped on the main casting. Vertical adjustment of the cutter is obtained by rotating this spindle in the frame, locking in any position being effected by the clamping handle seen in the photograph. The cutters are sharpened by being ground on their flat faces, and wear is taken up by adjustment of the top cutter.

In addition to the power-driven shearing machines, which we have described, the Tangent Tool Company also show their hand-operated machines for cutting corrugated iron in any direction, and for light shearing work generally. These we have previously illustrated in our columns, and we need not therefore do more than refer to them. Besides shearing machines, however, the company are exhibiting some very ingenious applications of hydraulic power to hand tools for punching and bending operations. All these tools embody a "Smith's hydraulic limit" in one or other of its standardised forms. This is a device which effects a large multiplication of the pressure exerted on the hand lever, and so enables a relatively enormous pressure to be applied to the work without undue demands on the muscles of the operator. In Fig. 9 we show the application of one of these hydraulic units to a spring-testing machine, enabling a pressure of 20 tons to be usefully exerted. The section through the hydraulic mechanism given in Fig. 10 makes the principles of its action clear. The ram has a stroke of 4 in., and is caused to descend by repeated strokes of the hand lever. The hydraulic advantage is 23 to 1, so that a total pressure of 20 tons is easily obtained, and this can be exerted through the whole of the 4-in. travel of the ram if there is sufficient resistance to the motion of the latter. One of the interesting features of the machine is that the ram can be coupled mechanically to the handle when desired, by means of a swinging link, thus putting the hydraulic multiplication out of action. This enables the ram to be raised or lowered through its whole range by one stroke of the hand lever, though of course the only pressure which can be exerted under these conditions is that due to the mechanical leverage.

The press operates as follows: For bringing the ram rapidly down to its work, the valve V, which is normally held up to its seating by a small helical spring beneath it, is opened by depressing the small cam-lever shown. The links which are jointed to the hand lever are then raised and the pin B inserted in the jaw at the end of the rod A. This rod is screwed into the ram, so that it is now possible to force the ram on to its job, the oil being sucked from the reservoir into the space above the ram through the valve V. This valve is now allowed to close by turning up the cam lever into its vertical position. The rod A is then released from the lever, and the depression of the latter forces down the annular plunger surrounding the rod. This movement displaces the oil and delivers it downwards through the hat-leather into the ram cylinder, thus causing the ram to descend. Further strokes of the hand lever draw more oil through the suction valve and force it into the ram cylinder. When the end of the power stroke of the ram has been reached, B is engaged with rod A, the valve V is opened and the ram withdrawn with a single stroke of the hand lever, the oil returning to the reservoir through the valve V. The hat-leather acts most efficiently as a non-return valve, and stands up to a load of 2·5 tons per square inch quite satisfactorily. The pressure exerted by the ram is read by a suitably-calibrated hydraulic pressure gauge as shown. A machine of this type is being exhibited at Birmingham testing the deflection of a powerful leaf spring, and other possible applications of the principle are obvious.

(To be continued.)

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—While local industry has unquestionably taken a turn for the better, the rate of progress is still disappointingly slow in many departments. This is noticeably the case in the tool branches, where prices, consequent upon recent cutting, are still too low to allow a reasonable margin of profit after covering working costs. A better understanding, however, is likely to be reached among manufacturers as a result of informal conferences which are being held. One of the best signs of confidence in the future is found in the fact that slight advances in bonus and tonnage rates have been made by several of the leading firms producing engineering materials and machinery. An improved demand is anticipated for builders' ironwork now that makers have reduced quotations by an average of 10 per cent. There is a good deal of discussion and some anxiety respecting the shortage of raw and certain semi-manufactured materials. Pig-iron is becoming scarcer, and is not obtainable at old rates. Lincolnshire basic is quoted as high as 5*l.*, and some of the Derbyshire masters are asking up to 6*l.* for foundry sorts. Consequently the market for iron and steel scrap is steadily hardening. Machinery cast-iron scrap for foundry consumption is quoted at 90*s.* per ton, and heavy wrought-iron scrap at 87*s.* 6*d.* delivered in Sheffield. The best steel scrap is offered at 85*s.* per ton compared with the boom price of 12*l.* following the armistice. In the machinery section, makers of electrical requirements are exceptionally well placed, and in turn find a good deal of work for foundries and steelmaking shops. Prospects are improving consistently in the colliery and railway sections.

South Yorkshire Coal Trade.—The latest export figures respecting South Yorkshire trade *via* Hull, show marked increases in shipments to Germany, Denmark, Holland and Sweden. At the moment there is a slight falling-off in Continental requirements, but this is principally brought about by loading delays. On home industrial account an increased tonnage is going into consumption. The demand for cobbles and nuts shows a steady expansion. Slacks are sharing in the general benefit and colliery sidings are free from stocks. Steady business is being done in best quality house coal. The coke market is strong in all departments. Quotations:—Best branch hand-picked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 21*s.* to 22*s.*; Derbyshire hards, 20*s.* to 21*s.*; rough slacks, 9*s.* 6*d.* to 11*s.*; nutty slacks, 7*s.* 9*d.* to 9*s.* 9*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Demand for Cleveland pig-iron is heavy, but business is on a very limited scale, the iron available for sale for anything like early disposal being trifling in quantity. Most makers are well sold to April, and in no hurry to commit themselves further ahead to any extent. A few more sales to America of special iron, low in sulphur and in phosphorus, are reported. There is now no No. 1 on the market, and the same may be said of No. 4 forge, mottled, and white. A little siliceous iron has been disposed of at 117*s.* 6*d.*, but it is doubtful whether repeat orders would be accepted at that figure. Small odd lots of No. 3 have realised 110*s.*, 112*s.* 6*d.*, and even more, and it is difficult to say what figure a prompt parcel would now realise. No. 4 foundry is quoted 107*s.* 6*d.*

Hematite.—East Coast hematite by its comparative cheapness continues to attract home and export buyers. A good and extending business is reported and supply is none too plentiful. More sales to Italy have been arranged, and a few lots have been disposed of for shipment to the United States. The minimum quotation for Nos. 1, 2 and 3 is 105*s.* Business has been done at 106*s.*, and some makers are inclined to hold out for rather more.

Foreign Ore.—Sales of imported ore are little heard of, but inquiry is rather better, and prices are stiffening. Best rubio is 24*s.* 6*d.* to 25*s.* c.i.f. Tees, and good Mediterranean ores are about 23*s.* 6*d.* c.i.f. Tees.

Blast-Furnace Coke.—Coke is very difficult to obtain. Local consumers are able to purchase essential supplies from firms they have dealt with for many years at 35*s.* to 36*s.* for medium furnace Durham kinds, notwithstanding that the export price is vastly above that figure.

Manufactured Iron and Steel.—Producers in all branches of finished iron and steel have good contracts made. Inquiries are, perhaps, hardly so numerous and heavy as they have been, but they are still on a very substantial scale. Shipbuilding material is still a good deal sought after; rails are selling fairly well, and demand for sheets is more than can be dealt with. Common iron bars are 11*l.*; iron rivets, 11*l.*; steel billets, 8*l.* 10*s.* to 9*l.* 5*s.*; according to quality; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 10*s.*; steel angles, 9*l.*; steel rivets, 12*l.* 7*s.* 6*d.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 13*l.* 10*s.*; black sheets, 13*l.* 10*s.*; while galvanised corrugated sheets are quoted at 13*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—With the gradual increase in the amount of plant in operation the Scottish steel makers are preparing to meet the increased demand for material which is surely making itself felt. That trade is getting better is undoubted, but the process is indeed very slow, and a considerable time must elapse before the old conditions are again in evidence. The booking of orders for plates and sectional material has been fairly good of late and quite a satisfactory tonnage is now fixed up. Inquiries are also good, and the prospect of many of these maturing before long is held to be almost a certainty. Export business is not opening out very quickly, however. In the black steel sheet trade there has been a welcome reappearance of orders for the heavier gauges, and coupled with the business on hand for the lighter sheets there is altogether a fair amount doing at the present time. Prices are being firmly maintained, and the following are to-day's market quotations:—Boiler plates, 12*l.* per ton; ship plates, 9*l.* 5*s.* per ton; sections, 9*l.* per ton; and sheets, 11*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The conditions in the West of Scotland malleable iron trade continue to improve and the demand during the past week, both on home and export account, has been fairly satisfactory. In the steel re-rolling branch the change for the better which has been noticeable for a week or two past continues, and some very respectable orders have lately been booked. Prices are firm, with "crown" bars called 11*l.* per ton delivered Glasgow.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade, a fairly healthy state is in evidence and outputs are being disposed of rather more freely. There is a fair home demand for foundry sorts, and the consumption of hematite at the steel works is gradually getting larger week by week. Foreign buyers are not very numerous at the moment, but some fair inquiries are again in the market. Prices are firm and are as follow:—Hematite, 5*l.* 10*s.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 10*s.* per ton, and No. 3, 5*l.* 5*s.* per ton, at makers' yards.

Shipments of Scottish Pig-Iron.—The total amount of Scottish pig-iron shipped from Glasgow Harbour last week was 4,897 tons. Of that total 4,116 tons went foreign and 781 tons went coastwise. During the corresponding week last year the figures were 280 tons foreign and 111 tons coastwise.

Institution of Engineers and Shipbuilders in Scotland.—A meeting of the Institution of Engineers and Shipbuilders in Scotland took place in the hall, Elmbank-street, Glasgow, last night, when the president, Mr. Harold E. Yarrow, C.B.E., occupied the chair. An interesting paper entitled "Vane-Wheel Propulsion," was read by Mr. Maurice E. Denny, C.B.E., D.Sc. The author said he believed that vane-wheel propulsion gave a higher efficiency than any other known method. As a result of experiments in Messrs. Denny's experimental tank and on a full-sized vessel in the Gareloch, it was found that by using vane-wheels a reduction in power of about 40 per cent. was obtained, as compared with a vessel driven by a screw propeller, while model trials comparing side paddle wheels with vane wheels showed a gain for the latter of about 30 per cent. and a similar set of trials with a stern-wheel model indicated a gain of 20 per cent.

EDUCATION OF GAS ENGINEERS.—The Institution of Gas Engineers, at a special meeting held at the Institution of Mechanical Engineers in London, on Wednesday, February 14, adopted a scheme for the education and certification of gas engineers, which has received the approval of the Board of Education. Under this arrangement, it is proposed to issue two certificates, which will be endorsed by the Board. The ordinary certificate will cover the work of three years' classes in general subjects, such as mathematics, physics, chemistry and elementary engineering. The higher certificate will be awarded after a further two years' study of gas engineering or gas supply and their cognate subjects. A scheme for the issue of a diploma in these subjects to those who, having the higher certificate in both gas engineering and gas supply, submit to a further examination, was also a part of the proposals.

CLYDE OIL FUEL SYSTEM.—On Thursday, February 8, the trials were carried out on the s.s. Fezaro, built by Messrs. Alexander Stephen and Sons, Limited, of Linthouse. One of the special features of the machinery installation of the vessel is the system of oil-burning which is due to the Clyde Oil Fuel System, Limited, of Glasgow. In this plant the body of the oil heater is cast solid, and holes are drilled through it for the insertion of the steam-heating coils which are of the Field type. The narrow annular spaces between the steam tubes and the drilled holes are used as the oil spaces, and are connected at the ends to provide a series path. All the steam coils being connected to only one header, there is little or no possibility of expansion troubles, and tightness is assured. No brickwork is used in the furnaces, but the whole of the air for combustion is given a definite circulation over pressed steel furnace front closing plates, which are shaped to carry the combustion well forward. The service conditions of the s.s. Fezaro are 12¼ knots at 3,150 s.h.p. In a trial of 4 hours 20 minutes' duration, the fuel oil consumption proved to be 5·9 tons. The mean shaft horse-power was 3,137, which gives the consumption of oil as 0·975 per shaft horse-power-hour. The actual mean speed of the vessel was 12¾ knots.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 16, at 6 p.m., at Storey's Gate, St. James' Park, S.W. 1. Annual General Meeting. Paper by Mr. H. C. Young, on "Some Mechanical Problems in the Rubber Industry."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 16, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette, "Notes on Some Insulating Materials," by Mr. T. L. Allison. Saturday, February 17, at 2 p.m., Visits to buildings in course of construction at Wembley for the British Empire Exhibition. Friday, February 23, at 7.30 p.m., Lecturette, "Characteristics, Operation and Maintenance of Underground Cables," by Mr. A. J. Tracey.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, February 16, at 7.15 p.m., at the University College, Singleton Park, Swansea. Paper on "Research and Industry," by Mr. F. C. A. H. Lantsberry, M.Sc.Tech.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, February 16, at 7.30 p.m., at Bolbec Hall, Newcastle-upon-Tyne. "A Review of Turbine Failures and Their Causes," by Professor A. Mellanby and Mr. William Kerr.

THE ROYAL SOCIETY OF ARTS.—Monday, February 19, at 8 p.m.: Cantor Lecture, "The Vulcanisation of Rubber," by Mr. Henry P. Stevens, M.A., Ph.D., F.I.C. (Lecture III.) Wednesday, February 21, at 8 p.m.: Ordinary Meeting, "Hand-writing and its Value as Evidence," by Mr. C. Ainsworth Mitchell, M.A., F.I.C. Sir Richard David Muir, Senior Counsel to the Treasury, Central Criminal Court, will preside.

THE BRADFORD ENGINEERING SOCIETY.—Monday, February 19, at 7.30 p.m., in the Hall of the Bradford Technical College, "Aerial Ropeways," by Mr. Harrison Roe.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Monday, February 19, at 7.30 p.m., at the Royal Technical College, Glasgow. Paper by Mr. J. L. Chaloner, on "High Speed Oil Engines."

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Monday, February 19, at 5.30 p.m., at St. John-street, E.C. 1. Lecture. "The Construction of the Atom," by Mr. H. Buckley, M.A.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, February 19, at 7.30 p.m., in the Lecture Theatre, Neville Hall, Newcastle-upon-Tyne. Paper by Mr. D. D. Stanier, B.Sc., Assoc.-M.Inst.C.E., on "The Watertight Fitting of Dock Gates."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 20, at 6 p.m., at Great George-street, S.W.1. Ordinary Meeting. Papers to be submitted for discussion: "Colombo Main Drainage," by Mr. Richard Eustace Tickell, O.B.E., M.Inst.C.E.; "Evolution in Sewage Disposal, with Special Regard to South African Experience in Sludge Treatment, Particularly at Pretoria," by Mr. Frank Walton Jameson; "Main Drainage of the Southern Suburbs of the City of Capetown, South Africa," by Mr. David Ernest Lloyd-Davies, M.Inst.C.E. Wednesday, February 21, at 7 p.m., Informal Meeting. Subject for discussion: "A Comparison of American and Canadian Methods of Engineering with English," to be introduced by Mr. G. W. M. Boycott, Assoc.-M.Inst.C.E.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, February 21, at 2.45 p.m., in Armstrong College, Newcastle-upon-Tyne. The following papers will be read and discussed: (*a*) "Organising for Production from Pot Furnaces," by Mr. W. W. Warren, Assoc. M.Inst.C.E.; (*b*) "The Effect of Boric Oxide on the Melting and Working of Glass," by Mr. F. W. Hodkin, B.Sc., and Professor W. E. S. Turner, D.Sc.; (*c*) "Some Physical Properties of Boric Oxide-Containing Glasses," by Violet Dimbleby, B.Sc., Mr. S. English, M.Sc., and Professor W. E. S. Turner, D.Sc.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, February 22, at 6 p.m., at Savoy-place, Victoria Embankment, W.C. 2. Lecture on "Transoceanic Wireless Telephony," by Dr. H. W. Nichols, to be followed by a discussion. Mr. B. Welbourne will exhibit two cinematograph films on "The Electrification of the Chicago, Milwaukee and St. Paul Railroad Company."

THE INSTITUTION OF LOCOMOTIVE ENGINEERS: LONDON.—Thursday, February 22, at 7 p.m., at The Engineers' Club, Coventry-street, W. 1, Sixth Ordinary General Meeting, Session 1922–23. "Training of Apprentices," by Mr. W. S. Edwards, Member of Council.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, February 21, at 7.30 p.m., at 49, Cromwell-road, South Kensington. The following papers will be read: (1) Discussion on "Reform of the Calendar," by Mr. Charles F. Marvin, Chief, United States Weather Bureau (the discussion will be introduced by Colonel E. Gold, F.R.S.); (2) "On the Growth and Decay of Vortical Systems," by Dr. S. Fujiwhara, Central Meteorological Observatory, Tokyo; (3) "On the Mechanism of Extra-tropical Cyclones" (Third Memoir on Vortical Phenomena), by Dr. S. Fujiwhara, Central Meteorological Observatory, Tokyo.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 23, at 9 p.m.: Evening Discourse will be delivered by Professor A. S. Eddington, F.R.S., Pres.-R.A.S., on "The Interior of a Star." Afternoon Lectures: Wednesday, February 21, at 3 p.m., Professor A. C. Pearson, Litt.D., on "Greek Civilisation and To-day: (II) Progress in the Arts"; Thursday, February 22, at 3 p.m., Professor B. Melville Jones, M.A., on "Recent Experiments in Aerial Surveying" (Lecture II); Saturday, February 24, at 3 p.m., Sir Ernest Rutherford, LL.D., D.Sc., F.R.S., on "Atomic Projectiles and their Properties" (Lecture II).

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, February 23, at 7.30 p.m., at the Engineers' Club, Coventry-street, London, W. 1. Mr. T. F. Hardyman will read a paper on "Machine Moulding Methods."

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The volume and value of South Wales coal shipments abroad in January was greater than in December when there were three less working days. In all, 2,398,248 tons of coal were exported from the principal ports valued at 2,803,274*l.* This represented an increase in volume of 136,362 tons and in value of 169,915*l.* The quantities shipped from each port was greater, except in the case of Newport. Shipments from Cardiff amounted to 1,494,839 tons, compared with 1,397,690 tons in December; from Port Talbot to 206,620 tons, against 199,748 tons; and from Swansea to 261,711 tons, against 208,468 tons. Exports from Newport were reduced from 455,980 tons in December to 435,081 tons in January. Exports of large steam coal amounted to 1,399,504 tons, at an average declared f.o.b. value of 26*s.* 5*d.* per ton, which was 5*d.* higher than in December, while shipments of steam smalls totalled 761,141 tons, an increase of 83,600 tons, at an average price of 16*s.* 10*d.*, an increase of 6*d.* per ton. The average price of large steam coal shipped from Cardiff at 26*s.* 9*d.* and from Newport at 25*s.* 6*d.* showed an increase of 5*d.* per ton, while that exported from Port Talbot at 26*s.* 11*d.*, was 7*d.* up, but the Swansea average at 26*s.* 9*d.* was 1*d.* down. The price of smalls was increased in all cases. Those shipped from Cardiff averaged 16*s.* 6*d.*, an increase of 4*d.*; those from Newport at 18*s.* 10*d.*, or 10*d.* up; and from Port Talbot 16*s.*, or 1*s.* 9*d.* up. The price from Swansea was 17*s.*, an increase of 1*s.* per ton. The slump in anthracite coal continues. Shipments of large from Swansea, at 95,000 tons, were 46,000 tons greater than in December, but the yield at 35*s.* 9*d.* per ton was 5*s.* 6*d.* lower. Exports of smalls at 61,400 tons were practically stationary, but the value at 18*s.* 6*d.* per ton was 7*d.* lower. Of the January exports those to France totalled 889,200 tons, compared with 768,000 tons in December, to Italy 305,100 tons against 273,400 tons, to Spain 135,300 tons against 143,700 tons, and to the United States to 205,100 tons against 10,700 tons. Those to South America were reduced from 391,400 tons to 302,100 tons, to Portugal from 96,000 tons to 89,600 tons, to Greece from 33,700 tons to 31,000 tons, to British coaling depots from 231,000 tons to 220,700 tons, to Canada from 27,000 tons to 1,500 tons, and to other countries from 320,700 tons to 252,800 tons. The question of extending the working hours of the coal trimmers and tippers at the South Wales docks has been the subject of a joint conference of the interests concerned. After an all-day sitting the men's representatives agreed to suggest to mass meetings the hours that should be introduced. The workmen's representatives stated that they were not prepared to agree to the suggested extension of hours, but would refer them to the workmen and would be willing to meet the employers and submit counter-proposals. In the circumstances the joint conference was adjourned for a week.

Iron and Steel.—The tin-plate stabilisation scheme has been extended for a further three months, and the minimum price of tin-plate bars advanced 5*s.* to 8*l.* 6*s.* per ton f.o.b., subject to a rebate to tin works of 7*s.* 6*d.* per ton. The minimum price of tin plates has also been increased by 6*d.* to 21*s.* f.o.b.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—A meeting of the Metropolitan District of this Institution is to be held at Stepney on Friday, March 2. At 10 a.m. the Mayor of Stepney will receive members at the Limehouse Town Hall. A paper by Mr. Belsher, borough engineer and surveyor, Stepney, is to be read and discussed, and visits will be paid to places of interest in the neighbourhood.

GLOSSARY OF AERONAUTICAL TERMS.—The British Engineering Standards Association has recently published a very useful and conveniently arranged glossary of the terms employed in aeronautical work, as a result of the revision of the glossary prepared by the Technical Terms Committee of the Royal Aeronautical Society and issued by that body in 1919. In its present form, the glossary is divided into sections covering general aeronautics, aeroplanes, airships, balloons, aircraft engines, airscrews, instruments, armament, meteorology and timber, and in each section the terms employed are logically arranged and clearly defined. In many cases, illustrations are given to assist the user, and a complete general index is also included so that any particular term can be readily located. The glossary as now revised, however, is still provisional, and in accordance with the usual practice of the British Engineering Standards Association, it will be subjected to further revision from time to time. The number of the publication is 185—1923, and it is obtainable from any bookseller or from the offices of the association at 28, Victoria-street, London, S.W. 1, price 1*s.* net, or 1*s.* 5*d.* post free.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

MR. R. A. CHATTOCK, M.I.E.E., CITY ELECTRICAL ENGINEER.

(*For Description, see Page* 193.)

FIG. 52. CANAL BASIN ARM ALONG FRONT OF BOILER HOUSE, NOVEMBER 11, 1921.

FIG. 53. CANAL BASIN ARM LOOKING TOWARDS SWITCH HOUSE, DECEMBER 2, 1921.

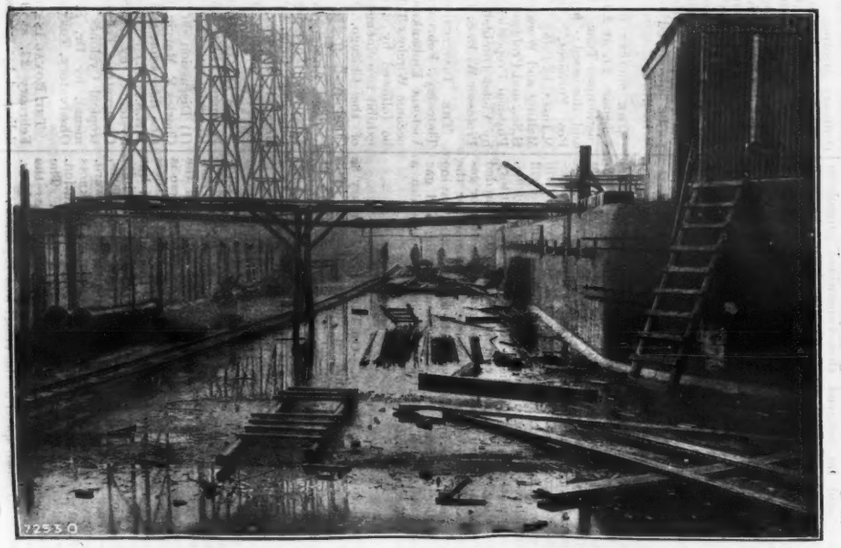


FIG. 54. CANAL BASIN ARM ALONG FRONT OF BOILER HOUSE, DECEMBER 22, 1921.

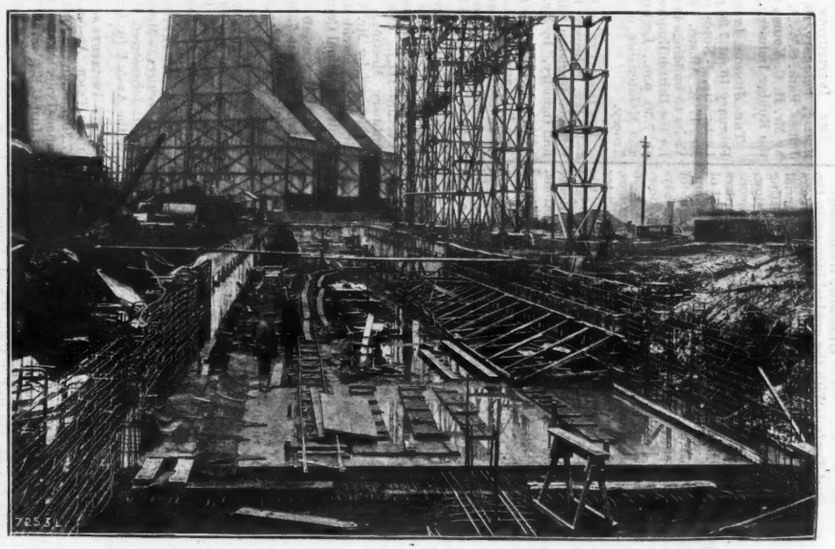


FIG. 55. CANAL BASIN ARM ALONG FRONT OF BOILER HOUSE, FEBRUARY 4, 1922.

FIG. 54. CANAL BASIN ARM ALONG FRONT OF BOILER HOUSE, DECEMBER 22, 1921.

FIG. 55. CANAL BASIN ARM ALONG FRONT OF BOILER HOUSE, FEBRUARY 4, 1922.

THE 360-H.P. ROLLS-ROYCE EAGLE IX AERO ENGINE.

CONSTRUCTED BY MESSRS. ROLLS-ROYCE, LIMITED, ENGINEERS, DERBY AND LONDON.

(*For Description, see Page* 212.)

Fig. 3.

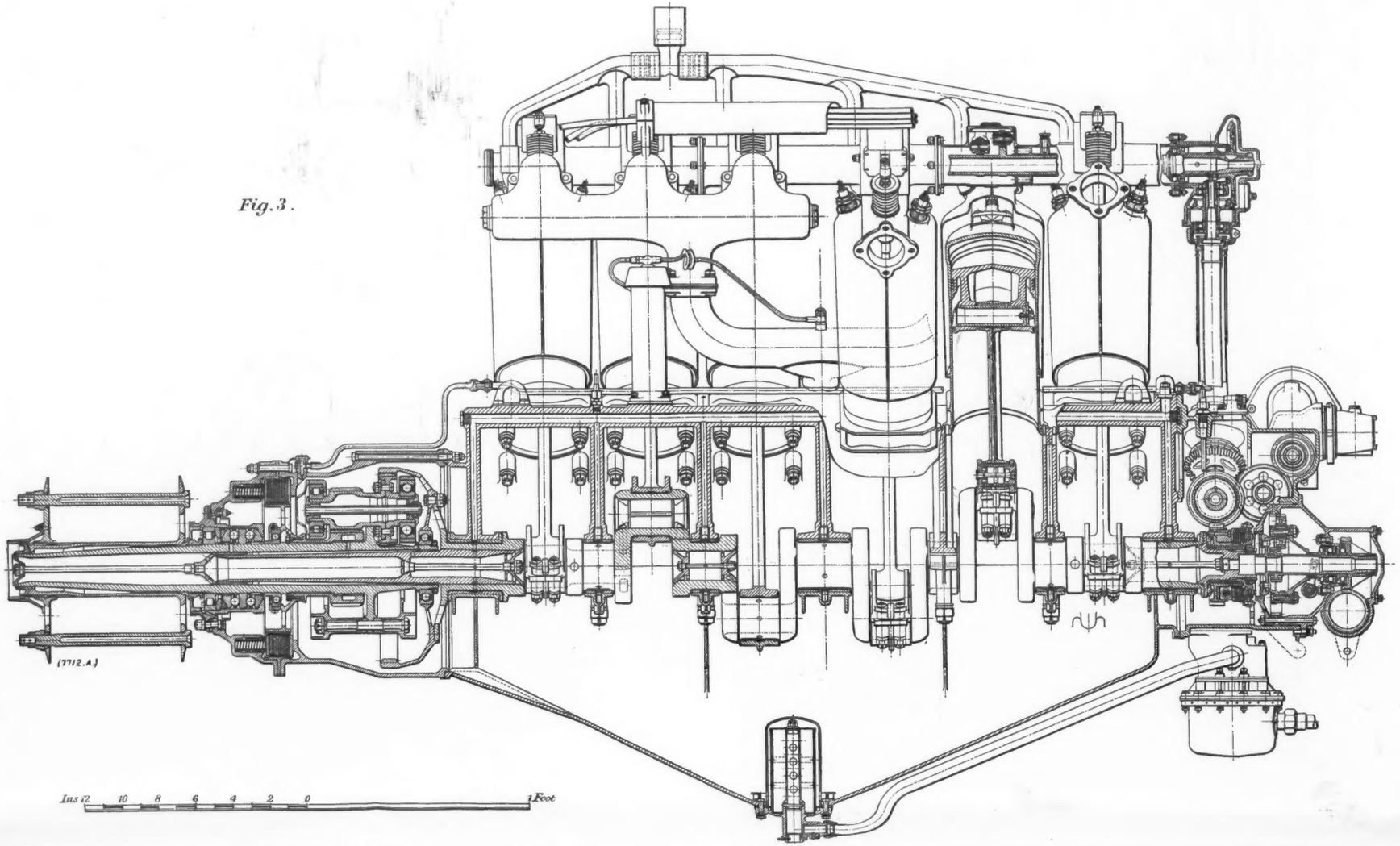


Fig. 4.

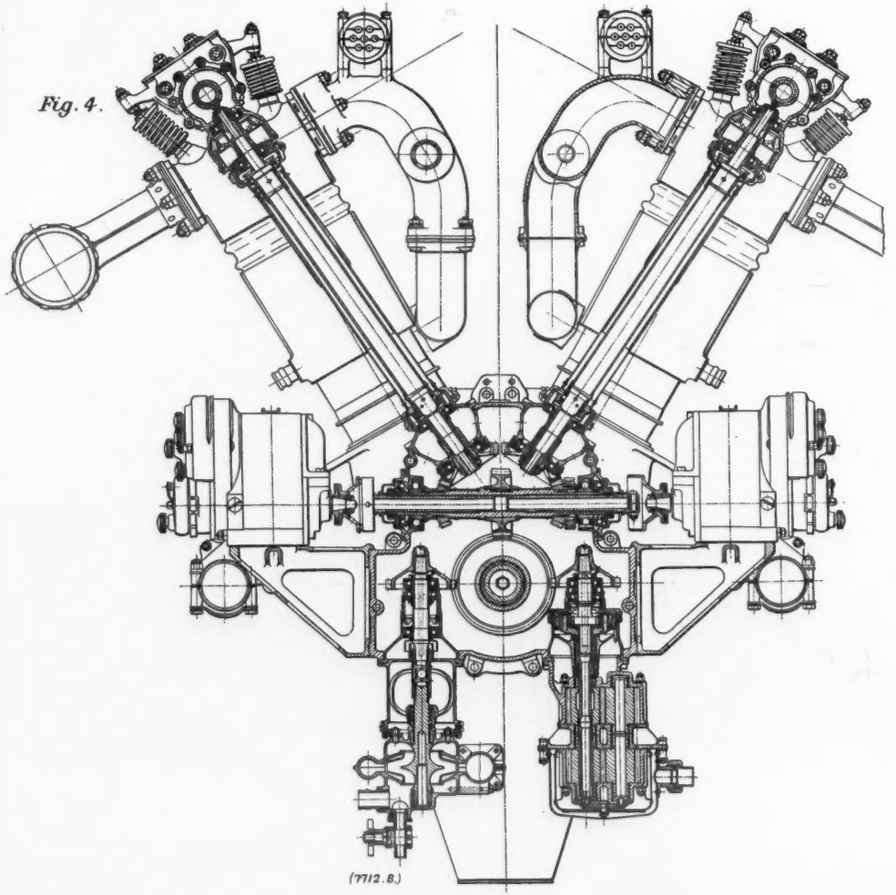


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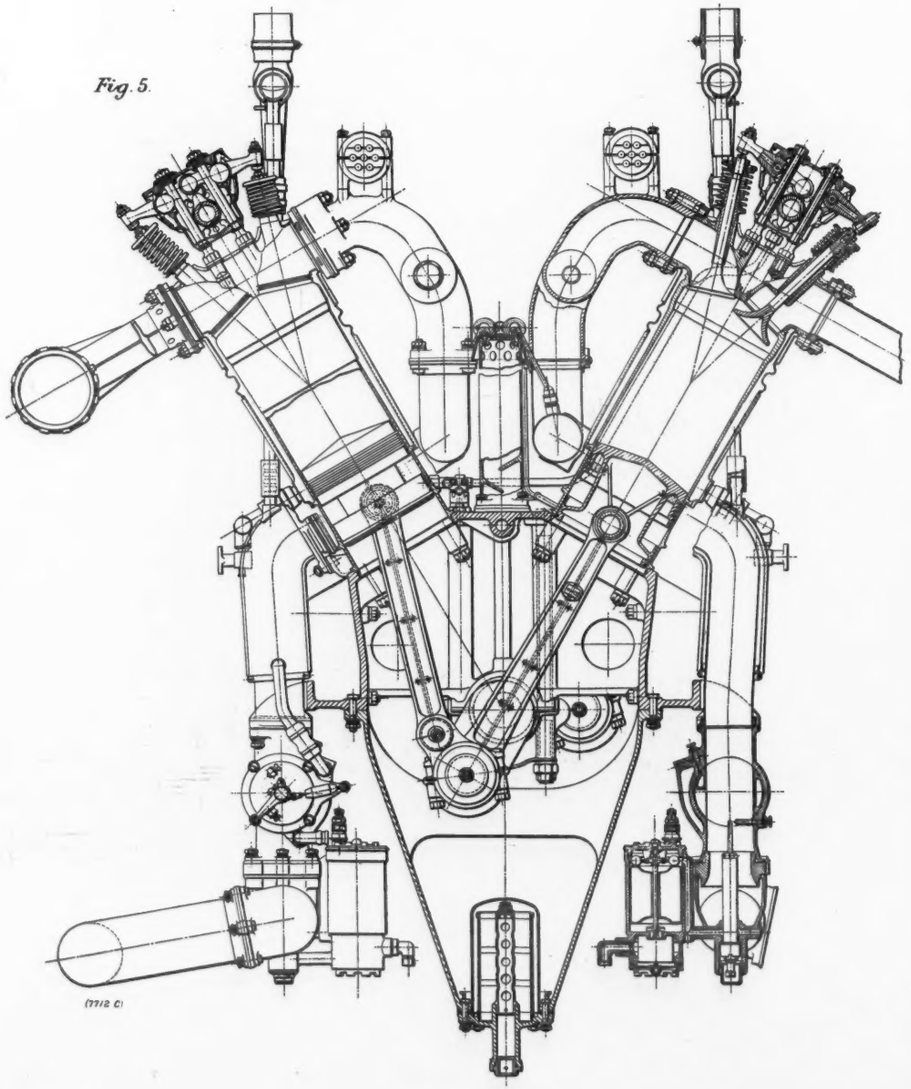
Fig. 5.



(7712 C)

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Two-Page Plate.—THE 360-H.P. ROLLS-ROYCE EAGLE IX AERO ENGINE.

ENGINEERING.

FRIDAY, FEBRUARY 16, 1923.

THE UNIFICATION OF ELECTRICITY SUPPLY IN LONDON.

IT is in keeping with the chequered history of electricity supply in London that practically coincident with the issue of the Draft Order constituting the London Joint Authority there comes the information that still another electricity Bill is to be introduced by some of the London supply companies. We cannot think that this Bill stands much chance of getting through Parliament, but the incident of its appearance illustrates how far opinion yet is from any general acceptance of the ideals for which the Electricity Act of 1919 stands. As the Bill is to propose that the right of purchase of company undertakings, which mature in 1931, shall be suspended until 1971, it is naturally to be opposed by the London County Council, which holds these powers. The Council would probably oppose the Bill on other grounds also, but this proposal to postpone its rights of purchase is in the nature of a direct attack on the position which it holds in the field of electricity supply.

The promotion of this Bill raises again the whole question of company *versus* bureaucratic control of electricity supply, and with every appreciation of the case which may be made for the former and the criticisms which may be levelled at the latter, we cannot think that the promotion is well advised. Time after time, and year after year, have attempts been made to introduce some sort of unification under company auspices, and time after time and year after year have they failed, and it may surely be admitted at this time of day that Parliamentary opinion has definitely hardened against any extension of powers in this matter to purely company interests. Parliaments in which different political parties have held majorities have acted in the same way, and any growth of public opinion which has taken place since the matter was first brought forward in a definite way has been against, rather than in favour of, the ideas for which this new Bill stands. The only practical policy at the present time is an acceptance of the principles of the 1919 Act and an effort to utilise them to improve the chaotic conditions now existing.

The last word on this matter naturally lies with Parliament, but this body is likely to support the recommendations of the Electricity Commission, which is their own creation. It is worth while noting that the Draft Order just issued constitutes the London and Home Counties Electricity District and establishes and incorporates the London and Home Counties Joint Electricity Authority. The next action takes the form of a further public inquiry for the examination of objections or proposed modifications to the scheme, after which the Order has to be approved by a resolution by each House of Parliament, and comes into operation. In establishing this Joint Authority the Commissioners are presumably acting on the assumption that there the various parties affected by the scheme are prepared to fall in with it. That this was their understanding of the outcome of the first inquiry was made evident by a statement which they issued in December, 1921, in the course of which they said "the Associated Companies agree to vest their generating stations forthwith in a Joint Authority upon certain conditions; the London County Council agrees to transfer to a Joint Authority its rights of purchase of the company undertakings, and, in consideration of the immediate transfer by the companies of their generating stations to the Joint Authority on certain terms, agrees to a postponement of the purchase of their distribution systems; the Conference of Local Authorities agree generally to the control of, or transfer to, a Joint Authority of the Local Authority generating stations, and to a settlement with the companies on the lines indicated."

It is presumably in the light of this understanding of the situation that the Commissioners have issued the Draft Order, but the promotion of the new Bill by the London Electricity Joint Committee suggests that some of the companies do not accept that reading of the situation. There would be no great value in speculating at any length on the way the new situation will develop, and one may wait to see the outcome of the further inquiry. The Electricity Commissioners have certainly always done everything in their power to obtain settlements by agreement in connection with all the electricity districts with which they have yet dealt, and it is certain that no efforts will be lacking in a similar direction in this latest case. It is none the less pertinent to remember that in this matter the last word rests with the Commissioners. No new generating station can be built and no existing generating station can be extended without their permission, and although the crude exercise of this authority would naturally hardly tend to immediate progress, the existence of these powers should be a considerable help towards some workable scheme being come to by agreement.

Although the essential purpose of the Electricity Act of 1919 was, after the creation of the Electricity Commission, the encouragement of the formation of Joint Authorities, alternative arrangements are not forbidden, and in the case of some districts matters are likely to be left in the hands of Advisory Committees. Such committees, which would represent existing generating and distributing authorities, would exercise general supervision and facilitate interworking and the arrangement of mutual concessions, but would have neither the authority or powers of a Joint Authority. In the case of a simple district containing only two or three important generating authorities such an Advisory Committee might work out an entirely practical and successful arrangement by which each authority concerned confined its activities to part of the area only, and mutual understanding was arrived at that no other body should interfere in the particular area marked off for another supplier. Given suitable areas this arrangement should give all the advantages of concentration and generation on an adequate scale which is the underlying purpose of the Act of 1919, but it is evident that it does not contain any proper principle of growth, and that if in the future it should prove necessary to introduce a generating system common to the whole district, the question of the formation of a Joint Authority, or something equivalent, would have to be faced. It is also evident that while an Advisory Committee might operate quite satisfactorily for such a simple electricity district as we have supposed, it would be quite unsuited to get the best out of the complicated

conditions which are represented by the London and Home Counties Electricity District.

The new Bill, which is to be promoted by the London Electricity Joint Committee in a sense falls in with the arrangements proposed in the Draft Order of the Electricity Commissioners. The Bill proposes the formation of a company to take over the generating activities of the existing companies, but would not be concerned with distribution. In a sense it would take much the same form as that of the existing Power Companies and would supply in bulk to the present companies, which would act as distributors. There is reason to believe that some understanding exists between the promoters of this Bill and the Conference of Local Authorities, which represents most of the municipalities concerned, and that the idea briefly is that the local authorities shall form their own co-ordinating organisation. Some such arrangement as this may be read into the proposals of the Draft Order since it is laid down that at their first meeting the Joint Authority shall appoint two committees, one consisting of the members appointed or elected by Local Authorities and the other consisting of the members appointed by the company undertakers. As we understand the Draft Order, however, these committees are intended to be of a temporary nature only, whereas the proposals behind the new Bill evidently contemplate a more or less permanent division between the two types of body. This difference is fundamental, and while the purpose of the Draft Order is to work towards a real ultimate unification, that of the Bill, while representing a real advance on the present state of affairs, does not propose any definite method of working towards the ultimate unity of control which is the ideal of the Electricity Act.

The outcome of this Bill, if it passed, would probably be the formation of something equivalent to the Advisory Committee we have described, and its maintenance until the end of 1971, which is the date to which the purchase clause is proposed to be extended. Quite apart from the objection to deferring unification until that time it is clear that this proposal which is necessary for the purposes of the Bill, is in itself a practically certainly fatal bar to it passing. These purchase rights are the property of the London County Council, and may be exercised in 1931, and it is not at all likely that the Council will be prepared to surrender them to the new company power supply organisation which is proposed. The goodwill and co-operation of the County Council is necessary in any satisfactory scheme which may be worked out for London, and in view of the apparently fairly general degree of agreement which has been reached for the scheme put forward in the Draft Order it will be unfortunate if the whole matter is to be thrown again into a state of flux.

THE PROBLEM OF THE HIGH-SPEED ENGINE INDICATOR.

It is possible that some disappointment will be felt that the discussion following the papers on Indicators read before the Institution of Mechanical Engineers centred to a great extent round the pencil indicator. It will not be disputed that this instrument has been perfected to a much greater extent than the high-speed type, and it is, therefore, a matter of regret that the difficulties encountered in the development of the latter were not discussed more thoroughly. In selecting modern high-speed indicators as the subject of three out of the four papers constituting the symposium, it is reasonable to suppose that the Council of the Institution were inviting a discussion on the most recent developments in this direction, and it is, therefore, surprising that certain well-defined difficulties in the design of this type of instrument were not even mentioned.

A somewhat fundamental difference of opinion exists as to the relative merits of the diaphragm and piston types, and it would have been of considerable help to designers if this point had received more attention. Fourteen years have elapsed since the late Dr. Watson published the results of a series of investigations in which he used the diaphragm indicator associated with his name, and, so far as we are aware, the diagrams which can be obtained with this instrument are as clear and accurate as those produced by any more recent type. The Watson indicator has been criticised as unmechanical, and as not being sufficiently self-contained to serve as a commercial instrument. To meet these objections, Professor Dalby has redesigned the instrument, although it may be mentioned that one of the original indicators used by Dr. Watson is in use at the present time, and is still giving satisfactory results. The criticism that the instrument is unsuitable for commercial work is to a great extent true of all optical indicators, and is almost entirely due to the fact that an artificial source of light is a necessity. One of the speakers, Mr. Johnson, pointed out that in one respect the Watson instrument is more suitable for direct application to the engine than the majority of others of the same type, as the mechanism for reproducing the piston motion forms part of the indicator itself, and that no rig for this purpose is, therefore, necessary.

In the discussion on the piston type, which is favoured by most modern designers, attention was devoted to the question of piston friction, and it was satisfactorily established that this can be reduced to an inconsiderable factor by suitable design, although, of course, it must always be present. Very little attention, on the other hand, was devoted to the other recognised point of weakness in the piston design, that of gas leakage past the piston. That this exists is sufficiently evident from the instrument designed by Professor Burstall, in which it is found necessary to introduce a transparent shield to prevent oil which has passed the piston lodging on the photographic plate. The magnitude of the error introduced by this leakage does not appear to have been definitely established, and it might be pointed out that it increases inversely as the size of the piston, and also increases with the pressure, so that it could not be neglected in such a case as that of an indicator applied to a Diesel engine, instanced by Mr. Crossley, in which the diameter of the piston would be reduced to one-eighth of an inch and the pressure would presumably be in the neighbourhood of 500 lb. per square inch.

Professor Burstall, in commenting on his indicator, mentioned that the size of the communicating passage between the combustion space and the indicator was a factor of great importance, and it is hardly too much to say that almost any shape can be given to the diagram by suitably proportioning the contour and diameter of this passage. It has long been recognised that a long and small bore connection, such as that used in the Charpentier indicator, results in very large errors, and we believe that the late Professor Hopkinson, in investigating this point, was able to vary the diagram considerably by merely altering the contour of a relatively short connecting pipe. Professor Burstall uses a perfectly straight passage of three-eighths of an inch bore, and his statement that accurate quantitative results cannot be anticipated if this diameter is appreciably reduced must be given very careful consideration by designers. It is only fair to state, however, that the late Dr. Watson made use of a short communicating passage of one-eighth bore, which was on occasion further reduced by the introduction of a coil of wire to damp out resonance waves, and it does not appear that the accuracy of the results has ever been seriously questioned. The fact that the mechanical efficiencies which were obtained in these experiments are approximately those which would have been anticipated from a study of the engines under test, suggests that any error which may have existed must have been of a minor nature. Mr. Judge, in commenting on this point in his book on high-speed internal-combustion engines, states that "too large a bore will also yield unsatisfactory diagrams, on account of frictional and viscosity effects due to the increased motion of the gases in the tube; further, a large volume of hot gases sweeping in and out of the indicator is very liable to damage the indicator."

Mr. Pendred, in his paper, and several of the speakers at the meeting, referred to the fact that, if the indicator was mounted directly on the engine, it was liable to be detrimentally affected by the vibrations of the latter. The only way to overcome this difficulty appears to be to mount the indicator on a structure separate from the engine foundation, as suggested in our article of January 12, and the advantage of this arrangement will be entirely lost if the pipe connecting the engine and indicator is too rigid to take up the engine vibrations. The dimensions and shape of this pipe are, therefore, matters of great importance.

The presence of waves at speeds of over 1,500 revolutions per minute in practically all the diagrams taken with the optical indicator which were shown at the meeting, and also in similar diagrams which have been published from time to time, is very noticeable, and one speaker suggested that such waves were rather desirable than otherwise, as indicating the absence of friction. This can be accepted in so far as the presence of such waves is preferable to their suppression by any damping device, but it must not be overlooked that these waves are merely a visual record of a defect in the instrument. They entirely preclude the possibility of a critical examination of the explosion and expansion curves whenever they occur, and their elimination ought not to be regarded as impossible at the speed at which modern petrol engines normally run.

As was pointed out by Mr. Pendred, with an engine running at 1,800 revolutions per minute, the portion of the diagram representing the explosion period takes only one-seven hundred and twentieth of a second to complete, and it follows from this that, if the diagram is 2 in. high, the point of light must travel at an average speed of 120 ft. per second over this portion of the curve. It would appear from this that, if a clear diagram is required, the source of light must combine a high actinic value with the maximum practicable intensity, and that, therefore, the arc lamp, although unsatisfactory in many respects, probably offers the best solution.

Before leaving the optical indicator, attention may be drawn to the Midgley instrument, which was not referred to at the meeting. This indicator possesses one or two special features which meet points of criticism raised by various speakers. The recording screen consists of a film stretched round a curved surface, with the mirror as centre, and no error, therefore, arises such as that produced when the point of light traverses a flat plate. This indicator is also interesting in that the stroke reproducing mechanism consists of a continually rotating cylinder, on which are mounted a number of flat mirrors, which come into successive operation as the cycle develops. This entirely eliminates inertia effects in the stroke element, and greatly simplifies the instrument, but it introduces the limitation that it can only be used for pressure-time cards.

Turning now to the electrical indicator, one of the speakers, Mr. Simms, pointed out that this type was not in any way likely to supersede the optical instrument, but that the two types were complementary, each having particular features which rendered it particularly suitable for different classes of investigation. The optical indicator, for instance, is especially suitable for examining the effect of such variations as alteration of the ignition setting or valve timing, while the electrical indicator is the only instrument available for really high-speed work or for operation from a distance. It appears probable that the electrical type is the more accurate of the two instruments, and should for this reason be selected for tests on mechanical efficiency. The electrical indicator appears to bring the problem of indicating the rotary engine appreciably nearer to solution.

The question of operation from a distance is one of great interest, as the psychological effect on the operator of working in close proximity to a powerful and noisy engine is likely to introduce a new term in the personal equation. In the R.A.E. indicator described the recording mechanism is positively driven from the engine, and the distance of the operator from the latter cannot be very considerable on this account. In the case of the Bureau of Standards electrical indicator, of which a brief description was given in our earlier article, to which we have already referred, the same restriction does not apply. In this instrument the movement of the diaphragm is utilised to complete a telephone circuit, and the record is thus rendered audible, and may be heard and registered at any desired distance. The effective distance, however, appears to be limited by the possibility of pressure drop in the pipe which

conveys the compressed air to the balance valve in the engine cylinder.

So far as we are aware, the only instrument which can be operated at any desired distance from the engine is Dr. A. M. Low's oscillograph manograph, of which a brief account appeared in the *Motor* of March 4, 1919. In this instrument both the pressure and stroke elements are operated electrically, the current for the latter purpose being taken from the magneto of the engine under test. This instrument appears generally to be very similar to that mentioned by Mr. Pendred in his paper as due to Professor Trowbridge, of Princetown University, with the exception of the method of operating the stroke mechanism, to which we have referred.

PATENTS IN IRELAND.

MANY people who own or are interested in patented inventions are inquiring what their position is, in view of the establishment of Dominion Government in the South of Ireland. Hitherto, patents which have been granted by the Crown have conferred a monopoly extending throughout the United Kingdom of Great Britain and Ireland and the Isle of Man. The Patent Acts, 1907–1919 give the patentee his remedy in respect of infringement in Ireland as fully in the Irish courts as if the patent had been granted to extend to Ireland only.

Up to the present, the creation of the Irish Free State has not altered this position. Article 72 of the Constitution states that laws in force in the Irish Free State at the coming into operation of the Constitution shall, provided they are not inconsistent with the Constitution, continue to be of full force and effect. The British Parliament has, however, by virtue of the Irish Free State (Agreement) Act, 1922, endowed the Irish Parliament with full power to legislate with reference to patents in the Irish Free State. But so far nothing has been done, and the British Patent Office still continues to issue patents in the same form as before—conferring a sixteen years' monopoly in Ireland as in other parts of the United Kingdom—subject to the due payment of such fees as are for the time being by law required. This grant must now, however, be taken as subject also to the reservation that its continued application to the South of Ireland is dependent upon such legislation as the Irish Free State may pass.

Such legislation, when it comes, must deal firstly, with patents already in existence, and secondly, with the initial grant of patents for Ireland. To set up in Dublin a Patent Office staffed and equipped for carrying out the work which the British Patent Office carries out as a preliminary to the grant of a patent is an undertaking which will involve considerable time and considerable outlay.

It may be that the Irish Parliament will be content in the first instance to set up merely a registration office, leaving the grant of patents, as it is at present, in the hands of the British Patent Office. It is scarcely likely that the Irish authorities, eager as they are for new sources of revenue, will abstain from levying some sort of tax upon patentees for the privilege of retaining their monopoly rights in the Free State. The establishment of a registration office would be a simple means to this end. There is nothing to prevent the Irish Parliament from passing a measure forthwith requiring registration of English patents in Ireland and the payment of a renewal fee to the Irish Patent Registration Office as the condition of the continued validity of a patent and the enforcement by a patentee of his rights in the Free State.

In the event of such action by the Irish Parliament, the question would arise whether the fees payable to the English Patent Office for the renewal of patents should not be proportionately decreased. In justice to the patentee this would seem to be only fair, since the scope of protection afforded by the grant of a British patent would, in the case assumed, have been reduced, inasmuch as the patentee could not pursue his remedies for infringement in South Ireland, unless he paid further fees for the registration and maintenance of his patent in the Free State. On the other hand, it would be urged by the Board of Trade that the expenses of the Patent Office were in no way lessened by the fact that the effective scope of the patent monopoly was diminished.

In considering the development of a patent system of its own, the Free State may derive assistance from the study of the systems already existing in other self-governing dominions of the British Empire. Canada, the Australian Commonwealth, New Zealand, the Union of South Africa, Newfoundland and India all have their own organisations for the protection of inventions by patent. In all these Dominions specifications are subjected to examination for the purpose of seeing that they are in proper form—and, except in South Africa, India and New Zealand, there is also an examination for the purpose of ascertaining whether the invention claimed is novel at the date of application. Initial payment for the grant of a patent ranges from 8*l.* in Australia to 2*l.* 13*s.* 4*d.* in India (at 15 rupees to the £). In Canada and Newfoundland no renewal fees are required; whereas in the other Dominions they range in aggregate from 5*l.* in Australia to 50*l.* in India.

Having regard to the fact that the South of Ireland has few industries to which patented processes are applicable, and that the likelihood of patents being infringed by actual manufacture in the Free State is small, the fees exacted from the patentees should be on a low scale.

Practically the only reason for maintaining a patent in Ireland would be to prevent the importation of infringing articles from abroad and their sale in Ireland. The Free State might very well become the dumping ground for cheap infringements. But this is notoriously the very class of infringement that it is most difficult to stop even with the most efficient and expeditious legal machinery. For such infringements are usually carried out by itinerant agents, men of straw, against whom an injunction is of little avail and a judgment for damages utterly valueless. The number of patentees therefore who will go to the trouble and expense of obtaining or maintaining patents in the Free State is likely in any case to be small, and the imposition of a high scale of fees would certainly act as a serious deterrent, when the advantages to be gained by patenting are so dubious.

TRADE UNIONS AND THEIR MEMBERS.

IN the case of Tierney *v.* The Derbyshire Miners and Bye-Product Workers' Union, in which Mr. Justice Sargant gave judgment last week, some wide and important questions were argued as to the powers of a trade union to alter its rules to the prejudice of existing members, but His Lordship was able to decide the main question at issue without giving judgment on them. The plaintiff was a miner, and joined the defendant union in 1902. He was then working in the Burley Colliery, which had shafts in Derbyshire and Yorkshire; but from 1906 onwards he worked in the Beighton pit, which had a shaft only in Yorkshire. The union had power to alter its rules in general meeting, and did so in 1910, 1916 and 1920. They considered that the effect of the alterations was to render the plaintiff no longer eligible for membership, in respect that he was working in a Yorkshire pit and not in Derbyshire, and they declined to accept further contributions from him and ceased to recognise him as a member. He claimed a declaration that their acts in excluding him from membership were *ultra vires*; a declaration that he was still a member of the union and entitled to the privileges of membership, and an injunction to restrain the union from excluding him. Apparently there had been a strike in the Yorkshire area in 1919, including Beighton Pit, and the plaintiff and some other members of the Union who went on strike had claimed strike pay although the union had not directed the strike. The case was of considerable importance to the union as well as to the plaintiff, as it would affect about one hundred men in all.

The 1920 rules were apparently practically the same as those of 1916, and the following were material to the case:—

"R. 1.—This Trade Union shall be known as the Derbyshire Miners and Bye-Product Workers' Union, and the members shall consist of as many persons employed (manual or clerical) in or about the various mines and bye-product works in Derbyshire, excepting South Derbyshire, as may join from time to time.

"R. 44.—Any member ceasing to work in or about a mine and bye-product works in this county shall no longer be a member of this Union, and secretaries must cease to accept any contributions, except as provided in Rule 69.

"R. 69.—A member on reaching the age of 50 years or beyond and being thrown out of work through causes over which he has no control, being unable to obtain work in the mines or bye-product works, and being obliged to accept work elsewhere, may by consent of the Council or Executive Committee preserve his connection with this Union for the purpose of obtaining old age pay. . . .

"R. 35.—Any member leaving a mine or bye-product works and going to work elsewhere where there is no branch of this Union shall be supplied with a clearance paper on payment of contributions up to date, but his membership of this Union must automatically cease, except in accordance with Rule 43."

The plaintiff's Counsel argued that, assuming that the rules as altered were sufficient to exclude the plaintiff from membership, the alterations were invalid, as any alteration, in order to be valid, must not deprive members of all the benefits to which they were entitled, and must not be used to expel any class of members from the union. Mr. Justice Sargant held, however, that under the rules, even as altered, the plaintiff was entitled to continue to be a member of the union, and it was therefore not necessary for him to decide anything as to the extent of the union's power to alter its rules. The plaintiff had joined the union under the rules of 1901, and those rules did not limit membership to persons working in mines in Derbyshire or provide for a member ceasing to be a member on going to work outside Derbyshire. Rule 1 of the 1910 rules provided that the union was to consist of its present members and as many persons as might join in accordance with the rules. There was again no limitation to collieries in Derbyshire. Under No. 1 of the rules, as altered in 1916 and 1920, no one could *join* the union who was not employed in or about collieries in Derbyshire, but the plaintiff was already a member, and there was no question of his joining the union. The union relied on rule 39 of the 1916 rules, which was to the effect that a member ceasing to work at a Derbyshire mine ceased to be a member, but the plaintiff had not ceased since 1916 to work in a Derbyshire mine. All that he was doing was to continue working where he had worked since 1906. The result of the 1916 rules, even as amended in 1920, was to leave as members of the union the existing members and only to apply the stricter qualification of employment at a mine in Derbyshire to persons joining under the new rules. The plaintiff was therefore entitled to a declaration that he was still a member of the union, and to an injunction restraining the union from refusing to accept his contributions. His Lordship indicated that in view of the objects of associations of this kind, viz., to deal with the relations between employers and employed, and in view also of the local character generally of such associations, it might well be held that the union could by an alteration of its rules provide not only for the future but also that existing members should not continue to be members if they were working in a different locality. He decided the case, however, on the narrower ground that the terms of the rules as altered did not exclude the plaintiff from membership.

NOTES.

THE PRESENT POSITION OF OIL ENGINE DESIGN.

On Wednesday evening last an excellent review of current practice with regard to the design of oil engines of various kinds was given by Mr. J. L. Chaloner in a paper entitled "High Speed Oil Engines" read before the Institution of Automobile Engineers. The author classified the different types of engines in accordance with their fundamental principles of operation, and found it quite possible to do so without introducing names of inventors or firms into the nomenclature. In this he showed a greater boldness than was evident in

the recent report of the Committee on Oil Engine Nomenclature. The main part of the paper, however, was devoted to consideration of the design of complete engines or of mechanical details, thus presenting in a handy form a large collection of matter of great interest to the designer. Tables giving the leading particulars of numerous engines, together with data as to their performances, and in many cases their respective heat balances, added to the value of the paper in question. Mr. Chaloner concluded by appealing for a simple system of nomenclature based on the technical characteristics of the various classes of oil engines, so that the name would define the type of engine and avoid the confusion at present existing. He considered that the limiting dimensions of the present types of engines were well known, being controlled by mechanical and metallurgical properties of the materials employed. No system of fuel utilisation which only yielded a maximum possible return of 50 per cent. would remain satisfactory to engineers, and Mr. Chaloner appeared to envisage the future discovery of some new and more efficient cycle for internal combustion. However this may be, the modern internal combustion engines are at present the most efficient machines known for converting fuel energy into work, and the author's review of those using oil as fuel is a most useful contribution to the literature of the subject.

The Treatment of Road Surfaces with Tar.

The Ministry of Transport (Roads Department) has issued during the past week a pamphlet entitled "General Directions and Specifications Relating to the Tar Treatment of Roads." The extent to which coal tar is used in road work is difficult to realise. It is true that in travelling about the country one cannot help being struck by the amount of tarred or tar-macadam roads now in service, but the fact conveys only a vague idea of quantity to the ordinary individual. The effect of this comparatively recent development is much more graphically brought home by the fact that the demand for road tar has become so great that the price has risen to a degree which has put the greater part of the briquetting trade in South Wales out of action. This industry which could be profitably run when tar was of moderate price, and which absorbed a class of fuel formerly practically waste, is now threatened with extinction owing to the demand for tar for road-making. An effort is on foot to have the price of tar officially controlled in order that the industry may be kept going. It would require an uncommonly astute economist to decide which of the two uses to which the tar is put is the more valuable to the country as a whole, and whether artificial regulation would really be justified. Its use on roads probably is of service to the greater number. The pamphlet just issued cannot fail to be of assistance to many surveyors and others whose experience in the matter has not been very wide. It gives practical directions on both tarring water-bound roads, and on the use of tar-macadam, detailing the best mode of preparing the road, in addition to laying and finishing. The specifications for qualities of tar suitable to these two uses are also sure to be welcomed, as to many road officials the characteristics of tar, which are of importance in such work, are none too clear. In fact, we question whether they have finally been determined, although experience has shown by now what type of specification will ensure the purchase of a suitable tar. The pamphlet (price 1*s.* net) may be obtained from H.M. Stationery Office, Kingsway, W.C.2.

Electrical Generation and Distribution.

Although very considerable growth has taken place in the amount of electrical energy sold by public supply authorities in recent years, the consumption per head in this country still lags far behind that of the United States and some other parts of the world. In this matter we are probably more backward in the domestic than in the industrial sphere, and any approach to the consumption which has been reached elsewhere is likely only to be attained by a careful cultivation of the small user. This condition lends great importance to the distribution side of the supply business, and there is little doubt but that an intimate knowledge of local conditions is necessary in any one who is to take full advantage of the possibilities in any area. This question was touched on by Mr. Wordingham in the Anniversary Lecture, which he delivered to the King's College Engineering Society, in the hall of the Institution of Electrical Engineers last Monday. Mr. Wordingham was dealing with the development of public electric supply in the United Kingdom, and, referring to the new Joint Authorities, suggested that, as a rule, it would be wise to leave distribution in the hands of local authorities who would not only have intimate knowledge of the possibilities and requirements of their own localities but would also have an interest in developing and improving them, which an outside body dealing with a very large area could not be expected to have. The occasion of Mr. Wordingham's address was the 75th anniversary meeting of the King's College Engineering Society, which is, we believe, the second oldest Engineering Society in the country. The lecture took the form of an illuminating survey of the early days and rise of the electrical industry, considerable attention being paid to the legislative efforts which with well-meaning blundering have hampered rather than helped it throughout its history. It has been suggested in more than one quarter that even to-day uncertainty about the ultimate effect of the latest legislation is hampering development, but one may be permitted to hope that when the new organisations are in proper operation, they will assist towards a more rapid rate of progress than has yet been seen.

The Institution of Structural Engineers.

The first annual dinner of this Institution since it changed its name from that of the Concrete Institute, by which it had been known for some fourteen years, was held at the Savoy Hotel on Wednesday night, February 7, the president, Mr. E. Fiander Etchells, being in the chair. The interest of the older Institutions in the development of a body specially devoted to structural work, was shown by the presence among the guests of Sir Charles Morgan, C.B.E., Senior Vice-President of the Institution of Civil Engineers, Captain Riall Sankey and Mr. J. S. Highfield, the immediate past-presidents of the Institutions of Mechanical and Electrical Engineers respectively. An innovation in the toast list, was a toast to "The Pious Memory of a Great Structural Engineer," John Smeaton, which was honoured in silence after a brief account of his life and work had been given by Mr. Ewart S. Andrews. In replying to the toast of "His Majesty's Services," proposed by Sir Charles T. Ruthen, Major General Sir W. S. Brancker, K.C.B., Director of Civil Aviation, expressed the opinion that aerial transport would be on a profitable basis within five or six years. At present there was not sufficient traffic, indeed the whole of last year's aerial traffic across the Channel could have been carried by three aeroplanes working hard. General Brancker seriously contemplated the possibility of flights at 300 m.p.h. and at 30,000 ft. elevation, and thought it reasonable to expect that America would be reached in 12 hours within the next ten years. Subsequent speakers included the Right Hon. Lord Riddell, the Right Hon. Mr. Justice Darling, the Rev. F. H. Gillingham, the well-known cricketer, and Major James Petrie. All the speeches were of a high order of merit, the scholarly humour of Mr. Justice Darling being greatly appreciated, while his caustic references to the appearance of a "Government building in Exhibition Road" as an example of the worst a structural engineer could do, were felt to be merited, both by engineers and architects. Altogether there were over 250 members and guests present, and the evening passed in excellent fashion.

THE ROLLS-ROYCE EAGLE IX AERO ENGINE.

The chief business of Messrs. Rolls-Royce, Limited, of Derby and Conduit-street, London, W. 1, is, of course, the manufacture of motor cars of a type which has acquired a world-wide reputation for reliability, efficiency and excellence of workmanship. They, however, undertook the manufacture of aero engines early in the war in order to meet the demands of the Air Force for these machines, eventually producing them in very large numbers. In all, four types were developed: the "Hawk" of 100 h.p., the "Falcon" of 280 h.p., the "Eagle" of 360 h.p., and the "Condor" of 600 h.p., but of these by far the most important was the Eagle. Of this engine many thousands were produced during the war, and the last of the war models, known as the Eagle VIII, has also been extensively employed in post-war machines, both for civil aviation and service work. Its chief characteristics were durability and reliability, and evidence of the latter quality may be drawn from the fact that it was selected with satisfactory results for such long-distance flights as the crossing of the North Atlantic by Alcock, the South Atlantic flight of Sacurdura Cabral, the England to Australia flight of Sir Ross Smith, and others. We may also mention the fact that, more recently, a De Havilland machine fitted with a Rolls-Royce Eagle VIII engine was successful in the reliability test flight round Great Britain last summer, thereby winning the King's Cup.

The Eagle VIII engine, although largely used for commercial work, was primarily designed, some six years ago, for the fighting services, but as a result of flying experience in both these applications, combined with extensive testing and experimental work, it has been found possible to effect several improvements in the design. A new model, known as the Eagle IX, has therefore been developed and has now been put into production, this engine having been designed with the requirements of civil aviation in view, in addition to those of the fighting services. In the new design alterations have been made in the construction and arrangement of the carburettors, and several modifications have been introduced in the engine itself in order to obtain smoother running, together with increased strength and improved wearing qualities. These features will doubtless appeal particularly to those interested in the development of commercial aviation in this country and elsewhere, and in view of the fact that the surplus old type Eagle VIII engines held in stock by the Government at the termination of the war have now been largely disposed of, the advent of the new engine is opportune.

The object of the present article is to describe the design and construction of the new engine, which we are able to do with the aid of the photographs and drawings supplied by the makers and reproduced on page 213, and on Plate XV, which accompanies this issue. The general appearance of the engine is well illustrated in Figs 1 and 2, which show the propeller end and the timing-gear end, respectively, but before commencing a detailed description we may give the following general particulars: The engine is of the twelve-cylinder, water-cooled Vee type, developing 360 h.p. at a normal crankshaft speed of 1,800 r.p.m., but a reduction gear is fitted which gives the propeller a normal speed of 1,080 r.p.m. The petrol consumption at the ground level, and at the above-mentioned speed and power, is 25 gallons per hour, and the consumption of lubricating oil under the same working conditions is 1 gallon per hour. The weight of the engine complete with reduction gear, propeller boss, exhaust pipes and screened ignition, but without radiator, water or oil, is 965 lb., which works out to 2·68 lb. per horse-power.

As will be seen from Figs. 1 and 2, on page 213, the cylinders, which have a diameter of 4½ in. with a piston stroke of 6½ in., are mounted separately on the crank-case in two rows of six along each side, the angle between the cylinder axes, in a transverse plane being 60 deg. The design of the cylinders is best shown on the right of Fig. 5, on Plate XV, this illustration being a transverse section of the engine. The cylinder barrels and heads are each machined from a single forging of 0·6 per cent. carbon steel, while the water jackets are of die-pressed sheet steel with oxy-acetylene welded joints; the cylinders are each fixed to the crank-case by four bolts passing through the corners of square flanges formed on the lower ends of the barrels. The valve seats are formed in the cylinder head, and the inlet and exhaust ports, which are machined from steel forgings, are secured to the cylinder heads by screwing and welding. One inlet and one exhaust valve only are used for each cylinder, and these are operated through rockers from overhead camshafts, one of which is mounted on top of each row of cylinders. The valves are machined from forgings of a special high-chromium steel, and they work in phosphor-bronze guides fitted in the ports as shown in Fig. 5.

We shall deal later with the method of driving the camshafts, but would now point out that they are enclosed in cast gun-metal casings carried by studs screwed into the cylinder head, as shown in Fig. 5. Each camshaft runs in five phosphor-bronze bearings, made in halves, bolted together and reamed in position. The material used for the camshafts is a 5 per cent. nickel case-hardening steel, and the shafts which are hollow, are machined from the solid bar and ground on the cam faces and bearing surfaces after hardening. The valve rockers are made from 3·5 per cent. nickel steel forgings machined all over. They are fitted with

hardened steel rollers to run on the cams, and have adjustable tappets, also of hardened steel, at the ends bearing on the valve stems.

The pistons are of the "Zephyr" type, and are cast from a special aluminium alloy. One is shown in section towards the right of Fig. 3, but the design can be more easily followed by reference to Fig. 5. As will be seen from the latter, the cylindrical surface of the piston is in two parts connected internally by substantial ribbed lugs. These lugs, which also carry the gudgeon pin, obviously give a much better support to the piston head than is obtained in the ordinary design of piston, and they have the additional advantage of transmitting the heat away from the head more readily. Four compression rings are fitted in the upper part of the piston and stops are provided to prevent these rings from rotating; there is an oil scraper ring at the base of the skirt as shown in both illustrations. The method of fitting the gudgeon pins is best shown in Fig. 3. The pins are machined from 5 per cent. nickel case-hardening steel, hardened and ground, and they are prevented from rotation or axial movement by a steel finger and locking plate fitted at the right-hand end of the pin in Fig. 3. The connecting rods are of the articulated type, those of the right-hand row of cylinders in Fig. 5 working directly on to the crankshaft, while those of the left-hand row of cylinders work on wrist pins fitted in the big ends of the other rods. The rods are of the usual H-section and are made from drop-forgings of 3½ per cent. nickel steel. They are machined all over to ensure uniformity in weight, and are heat treated to secure the necessary high degree of tensile strength and toughness. The big ends of the main rods are lined with white metal, while the small ends of the main rods, and both ends of the articulated rods, are fitted with phosphor-bronze bushes.

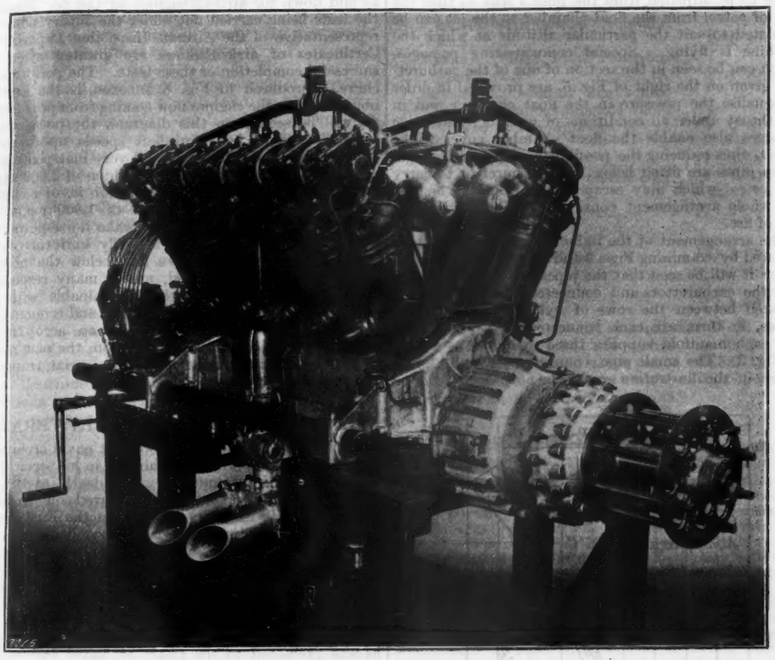


FIG. 1.

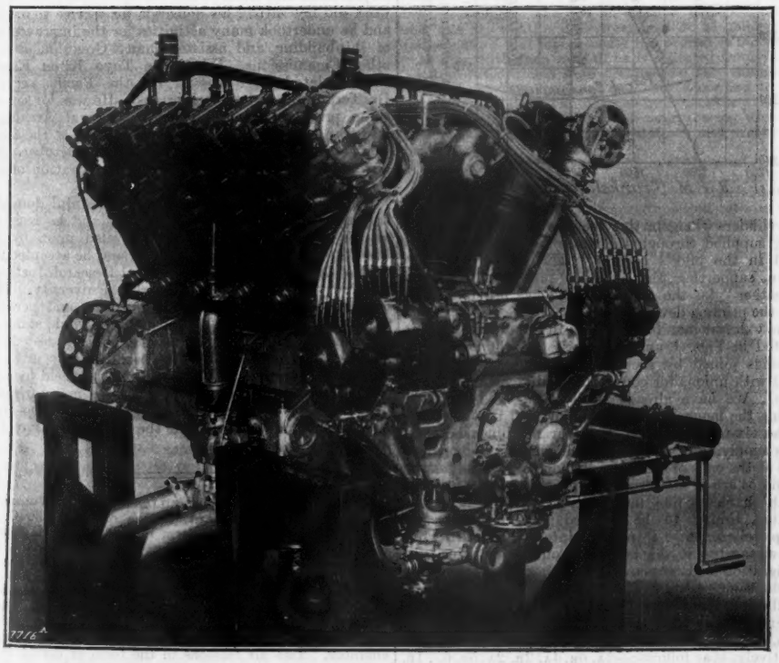


FIG. 2.

The design of the crankshaft is well shown in Fig. 3. It is, of course, of the six-throw type and is made from a forging of nickel-chrome steel machined all over and finished by grinding on the crank pins and journals. As will be seen from the illustration, the journals and crank pins are all bored out to reduce the weight, but the ends of the holes are closed by stoppers so that the holes can be used as passages for the lubricating oil. The crankshaft runs in seven main bearings fitted into the upper half of the crank-case, the caps, which are of nickel steel, being secured by long bolts. as will be understood on reference to Fig. 5. The bearings proper, consist of split phosphor-bronze shells lined with white metal. The upper half of the crank-case is a substantial casting of aluminium alloy formed with diaphragms at each of the intermediate bearings, while to each corner of this part of the crankcase brackets are bolted externally for supporting the engine on tubular bearers; these brackets can be seen in the half-tone engravings, Figs. 1 and 2 annexed. The lower half of the crankcase, which serves as an oil sump and to enclose the working parts, is a lighter casting of the same material; it can easily be removed to enable the working parts to be inspected. Stiffening ribs of the form illustrated in Fig. 5 are provided in the positions indicated by cross hatching in Fig. 3.

In order to obtain the maximum efficiency in both engine and propeller it is necessary to run the latter at a lower speed than the former, and for this reason an epicyclic reduction gear is incorporated in the engine design to transmit the power from the crankshaft to the propeller hub; the ratio of reduction is 1 : 0·6. The first element of the gear, which is shown in section on the left-hand side of Fig. 3, is an annular driving wheel bolted to a flange formed on the crankshaft, and having at its centre a ball bearing in which the inner end of the propeller shaft runs. The annular wheel drives three pairs of planet gears mounted in a frame which forms the driven member and is bolted to a flange on the propeller shaft. The planet gears run in ball and roller bearings mounted in the frame, and the smaller wheel of each pair gears with a stationary sun wheel through which the propeller shaft passes. The sun wheel is normally prevented from rotating by means of a multi-plate clutch, the alternate plates of which are anchored to the casing and to a sleeve connected with the sun wheel, the plates being pressed into frictional contact by means of a number of helical springs. It will be evident that, with this arrangement, the clutch will slip and allow the sun wheel to rotate, more or less, if the torque becomes excessive, due to propeller vibrations or pre-ignitions; by this means the maximum stresses on the gears are kept within the designed limits. The makers claim that the use of epicyclic reduction gearing arranged as described prevents any reaction from the pressures on the gear teeth from being transmitted to the crankshaft bearings and gives the highest possible efficiency.

The wheels, and all other wearing parts of the reduction gear, are made from 5 per cent. nickel case-hardening steel and the propeller shaft is of nickel-chrome steel of similar composition to that used for the crankshaft. As previously mentioned, the inner end of the propeller shaft is supported by a ball bearing at the centre of the annular driving gear, and support for the outer end is provided by a large roller bearing fitted at the end of the gear casing close to the propeller hub; a double thrust ball bearing is also fitted in the casing, as shown in Fig. 3, to take the propeller thrust. The propeller hub is machined from forgings of 3½ per cent. nickel steel, and is secured to the propeller shaft by longitudinal serrations formed on the inner surface of the central hole of the hub engaging with similar serrations on the shaft. A split conical phosphor-bronze ring is fitted to the shaft close to the gear casing and a conical nut is screwed on to the outer end. The cone surfaces of the ring and nut, which are tapered in opposite directions, fit into conical seatings formed in the hub and this arrangement serves to centralise the hub and to secure it against axial movement. The loose flange is fitted to the hub by means of serrations and the propeller is secured by long hollow bolts which pass through the boss.

At the rear end of the engine, assuming it is to be used with a tractor propeller, are situated the auxiliary gear and camshaft drives, together with the hand-starting gear. These are shown on the right of Fig. 3, and also in Fig. 4, and, as will be seen in these illustrations, are all driven from a single helical gear mounted on an extension of the crankshaft, but connected to the shaft extension through the medium of a spring-controlled friction damping device. The latter resembles a small plate clutch in design and its object is to prevent

any torsional oscillations of the crankshaft from being transmitted to the auxiliary drives; the range of movement permitted by the controlling springs is, however, too small to affect the timing. Reference to Fig. 4 will show that the helical gear drives a short transverse shaft on which are mounted two bevel wheels operating the camshaft drives, while on the ends of the shaft are couplings driving two of the magnetos. Four magnetos are employed for the ignition, and the other two are operated in a similar manner from a second transverse shaft driven from the first by spur gearing, clearly shown in Fig. 3; the method of driving the oil and water circulating pumps from the helical gear on the crankshaft will be understood on reference to Fig. 4 without explanation. All the gears, it should be mentioned, are of 5 per cent. nickel case-hardening steel and all the shafts run in ball bearings.

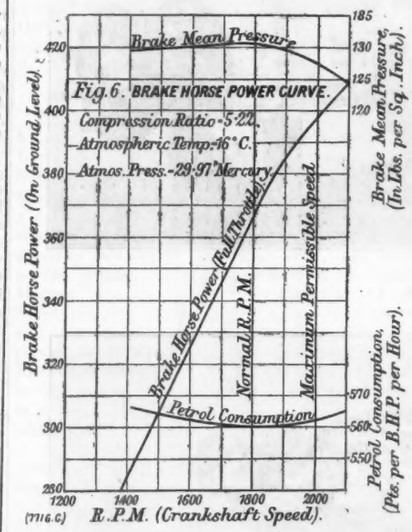
The camshafts are driven from the bevel gears on the transverse shaft, above referred to, through inclined tubular shafts with bevel gears at the upper ends engaging with similar gears on the end of the camshaft, as clearly shown in Figs. 3 and 4. Hardened serrated couplings are fitted at both ends of the driving shafts to allow for the effects of expansion or lack of alignment, and the shafts themselves are totally enclosed in tubular casings.

The hand starting gear is of the epicyclic type, giving a speed reduction between the handle and the crankshaft of 9 : 1. The handle, which can be seen in Fig. 2, can, of course, be placed on either side of the engine to suit requirements; it is supported as shown by a clip on one of the engine bearers. The gear differs from the main reduction gear in that the sun wheel is the driving member, the annular gear being fixed. The sun wheel is rotated by means of the handwheel operating through a pair of helical gears shown on the extreme right of Fig. 3, and the crankshaft is turned by the cage carrying the planet gears. The front face of the cage and the rear face of the friction damping device have jaws machined on them so as to form a claw clutch, engagement of which is effected by sliding the cage along its shaft. The pivoted fork used for this purpose is shown in Fig. 3, and the other details of the mechanism can all be followed by examining this illustration.

Very careful attention has, of course, been given to the lubrication of all the Eagle engines, and this feature has doubtless had considerable influence upon the reputation the engine has gained for reliability. In the new model to which we are now referring, the dry sump system of lubrication is employed, the bulk of the oil required being carried in a service tank separate from the engine. From the service tank, the oil is drawn through a filter by a pressure pump of the gear type (the lower one of the two on the right-hand side of Fig. 4), and delivered at a pressure of about 40 lb. per square inch into a passage formed in the upper side of the crankcase. From this passage, other passages lead down to the main bearings and at the bearings the oil passes through register holes into the crankshaft. Holes in the webs of the latter allow the oil to flow to the crank pins, where it passes out again through other holes lubricating the big ends and flowing up to the gudgeon pins through copper pipes clipped on to the connecting rods. The splash from the big ends, &c., is sufficient for the lubrication of the cylinder walls. A compound relief valve is fitted in the main delivery of the oil system to regulate the pressure and also to provide an auxiliary supply of oil at about 5 lb. per square inch for lubricating the camshafts, camshaft drives and other auxiliary mechanisms. The camshaft is lubricated by oil supplied through a copper pipe to the bearing at the propeller end of the engine, the oil passing into the shaft through register holes in this bearing and out through similar holes in the other bearings. The surplus oil collected in the camshaft casings flows through the camshaft drive casings into the crankcase where the whole of the used oil from all parts of the engine is collected. From this it is drawn by the scavenge pump and returned to the service tank. The scavenge pump is the upper one of the two shown on the right of Fig. 4, and it should be noted that its capacity is slightly greater than that of the pressure pump, so that the crankcase is always kept clear of oil. The cooling water is circulated by the centrifugal pump shown on the left of Fig. 4. This needs no particular comment, but it may be pointed out that all the water pipe connections are formed by short lengths of rubber hose secured by a special patented type of clip, the arrangement giving ample flexibility.

One of the points of difference between the Eagle IX engine and the previous models is that, in the latest type only two carburettors are employed, instead of four, which facilitates engine tuning and has other advantages. The carburettors, it will be noticed from Fig. 5, have been placed as low down as possible and this, in conjunction with the fact that the float feeds have been re-designed, enables the engine to work satisfactorily with a head of petrol of only 8 in. above the level of the centre line of the crankshaft. This feature considerably facilitates the arrangement of the tanks in designing an aeroplane, and, in some cases, would enable a gravity feed to be adopted instead of a pressure feed. The carburettors are of the Rolls-Royce Claudel-Hobson type and each supplies one row of six cylinders. They are fitted with a device which enables the needle valve to be adjusted from the pilot's seat so that the flow of petrol from the float chamber to the jet can be regulated to suit the particular altitude at which the machine is flying. Special compensating passages, which can be seen in the section of one of the carburettors given on the right of Fig. 5, are provided in order to equalise the pressure in the float chamber and in the throat under all conditions of working, and these passages also enable the float chamber cover to be sealed, thus reducing the possibility of petrol leakage. Drain pipes are fitted below each carburettor to carry any petrol which may escape away from the engine, the whole arrangement considerably diminishing the risk of fire.

The arrangement of the induction pipes can best be followed by examining Figs. 3 and 5 together. From the latter it will be seen that the pipes are water-jacketed near the carburettors and connected with "U" pieces situated between the rows of cylinders. The "U" pieces, in turn, are each connected to two manifolds and each manifold supplies three cylinders as shown in Fig. 3. The small pipe connected with the "U" pieces in the illustration are for the purpose of priming



the cylinders when starting the engine, atomised petrol being supplied through the pipes from a hand pump fitted in the pilot's cockpit. The cylindrical body shown supporting the priming pipes is merely a "breather" for the crankcase and has no connection with the priming device.

The exhaust manifolds, shown in Figs. 4 and 5, but omitted in Figs. 1 and 2, consist of light sheet-steel pressings joined by acetylene welding and these are fitted with unions for connecting to light-steel exhaust pipes. We have already dealt with the method of driving the magnetos, but may now add that they are of the six-terminal type, the four machines between them supplying two plugs on each cylinder. The couplings at the ends of the transverse driving shafts for the magnetos are of the serrated type and include a device which enables a fine and positive adjustment of the ignition timing to be effected. The magnetos are completely screened to prevent interference with wireless apparatus, if this is carried on the machine, and the ignition leads are covered with metallic armouring for the same reason. The order of firing the cylinders, numbering them from 1 to 6, counting from the propeller end and lettering the left-hand and right-hand rows, as seen from the timing gear end, A and B, respectively, is as follows:—1A, 6B, 4A, 3B, 2A, 5B, 6A, 1B, 3A, 4B, 5A, 2B. Arrangements for ignition and throttle control are, of course, fitted on the engine and the lay shafts for this purpose are visible in Fig. 2, but the method of operating these from the cockpit, naturally differs according to the machine on which the engine is installed. For driving the revolution counter, a connection, running at one-fourth the crankshaft speed, is provided on the timing-gear case and a pump for supplying air to the fuel tank, when a pressure-feed system is employed, can also be mounted on the timing-gear case if required.

Since the reputation of the makers is so well known it is perhaps hardly necessary to add that the utmost care is taken in the selection and testing of the materials used for the construction of the engine, as well as in the whole of the workshop processes, to secure efficiency and reliability in the final product. After completion, the engines are tested in accordance with the Schedule of Standard Production and Type Tests as laid down for aircraft engines by the Air Ministry, the tests being carried out under the supervision of a representative of the Aircraft Inspection Department. Certificates of airworthiness are granted after the successful completion of these tests. The performance curve, reproduced in Fig. 6 annexed, is the average obtained from the engines now coming from production. As will be seen from this diagram, the power curve remains straight for crankshaft speeds up to about 1,850 r.p.m. and does not fall off very materially until speeds above the permissible maximum of 2,000 r.p.m. are reached. The petrol consumption is, of course, a minimum at the normal speed of 1,800 r.p.m., at which it reaches 0·56 pint per brake horse-power per hour, but the consumption is fairly uniform over a wide range of powers above and below the normal. The results, we understand, are in many respects a distinct improvement on those obtainable with the Eagle VIII engines, and as reliability and economy are the most important *desiderata* in an aero engine, especially when used in civil aviation, the new model should be particularly interesting to aerial transport concerns.

THE LATE PROFESSOR SEIICHI TERANO.

JAPAN has lost one of her foremost naval architects, and a man who never stinted himself in his services for the welfare of his country, by the death, at the age of 54, of Dr. Terano, which occurred on Monday, January 8. He graduated in 1890 at the Engineering College of the Tokyo Imperial University, and later became Assistant Professor of Naval Architecture in the college, and came to Britain to extend his knowledge of the subject. He continued his scientific work in Glasgow University and acquired further practical experience in the shipyard of Messrs. John Brown and Co., Limited, at Clydebank. After returning to Japan, he was promoted to the Chair of Naval Architecture and was later joined by Professor Hillhouse, who now occupies the Chair in the same subject at Glasgow University. In 1910, Dr. Terano was made Head of the Department and Dean of the College. His professorial work did not satisfy his demands for service to Japan, and he undertook many activities for the improvement of shipbuilding and assisted many Government and other Commissions. When the Toyo Kisen Kaisha comtemplated large vessels for the Pacific service, Dr. Terano supervised the designs. He was for several years president of the Society of Naval Architects of Japan, and was re-elected to that office at the semi-jubilee meetings of the society last October. He developed the scheme of Japanese registration of her own shipping.

Some two and a-half years ago, a painful domestic tragedy sapped much of his vitality and he resigned all his offices, but was later prevailed upon by his friends to resume his old activities, and he accepted the post of Director of the Aeronautical Research Institute in connection with the Imperial University. This work he took up with great enthusiasm and perhaps with greater effort than his constitution would stand.

A man of great purpose, personal disinterestedness and probity, who had an intense desire to advance whatever course he had in hand, he was held in high esteem, confidence and affection by his many friends. The Emperor of Japan conferred on Dr. Terano high court rank and the Order of the Sacred Treasure for his services to his country.

MESSRS. VICKERS AND BRAZILIAN HARBOUR WORKS.—Harbour engineering plant, to the order of the Companhia Mecanica Importadoro, Sao Paulo, is in course of construction at Messrs. Vickers, Limited, Barrow, for the Government of Brazil, for use at the Rio de Janeiro Harbour, and in other Brazilian ports where extensive under-water work has to be carried out, for excavating foundations and erecting concrete retaining walls. The plant consists of three units, each of which comprises two floating pontoons and an under-water working chamber. Two air caissons in the form of diving bells will be used for working at the greater depths. A third working chamber in the form of a cofferdam will be used for continuing, under atmospheric pressure conditions, the work commenced in the air caissons. The air caisson and cofferdam are suspended and operated from two floating pontoons trussed and braced together, their lowering and raising being effected by means of hydraulic jacks. The pontoons carry an equipment of electric cranes, concrete mixing apparatus and the requisite power plant. Powerful mooring apparatus are provided in order that the position of the air caissons and cofferdam be accurately maintained. Access for the men and material in the air caissons is by means of trunks and airlocks in the usual way for under-water caisson work.

INDUSTRIAL NOTES.

FOLLOWING our note on page 171 *ante* with reference to the Govan ship joiners who refused to accept work in the yard of Messrs. Harland and Wolff, Belfast, the Chief Insurance Officer has ruled that 63 of the men had by their refusal forfeited their right to benefit; in the case of 35 others, where the circumstances were somewhat different, the payment of the dole is to be continued. It is reported that the former men may probably appeal to the Court of Referees.

The adjourned meeting on the question of overtime on exceptional and urgent work, and on night shifts in shipyards announced in our last issue, took place on the 8th inst., and was followed by another meeting the next day. The only announcement made was to the effect that the men's negotiating committee was to report at a conference of the Federation of Engineering and Shipbuilding Trades, to be held at York on the following Thursday (yesterday). It was also agreed on both sides not to publish as yet the terms so far negotiated.

Speaking last Saturday at a meeting of the Middlesbrough and District Association of Foremen Engineers and Chief Draughtsmen, Mr. G. M. Harroway, vice-president of the North-East Coast Institution of Engineers and Shipbuilders, suggested that the alteration of the trade union idea of minimum wage would inspire men to do their best. The minimum wage, an artificial estimate of labour, was wrong in principle and went against Nature's laws. Wages should be paid in accordance with individual effort. There were many first-class men groaning under the union rules, and it was high time that these were altered so as to allow men to give of their best and be paid accordingly. There was no sound reason why unfit men should be forced upon industry, become a drug to proper and efficient management and cripple the national production. It would be far better to let the Government or municipalities provide workshops of some description for these men, and if they were not able to earn a living after honestly trying, then such an amount must be subscribed as to enable them to live in decency and comfort. Mr. Harroway further stated that there was no longer need for a long term of apprenticeship. What was needed was apprentices who would use their brains. For our engineering and shipbuilding industries to maintain their position required all the effort and hard work that directors, management and men could possibly give.

Organised labour, reports *The Iron Age*, New York, is no respecter of institutions, even of one serving its own ends. The international labour office of the League of Nations, Geneva, Switzerland, has announced that owing to a strike in the establishment where its bulletins and reports are printed, the appearance of further publications will be delayed.

The congestion at the docks in South Wales, to which we referred in several former issues, has not improved. It has been stated recently that although 70,000 wagons full of coal are standing at the Welsh colliery sidings and docks, there are at the present time 450 empty ships waiting to be loaded at the Welsh ports. The Welsh coal mines are greatly inconvenienced by the failure of the docks to deal with the output. It is reported that 50 vessels are held up each day. The men's leaders say the congestion is not a result of restrictions put upon coal tippers and trimmers, but of inadequate facilities at the docks and lack of co-ordination. The coal export trade is one of such vast importance to the nation that they might endeavour to make the best of the arrangements such as they are and, as the case may be, provide the local authority in every port with actual proofs that their contention is really the right one, when means most certainly would be taken to improve matters where lack of facilities actually existed.

A dispute as to wages occurred a few weeks ago in the London bookbinding trade which threatened to involve the London printing industry generally by "sympathetic strikes." Why such a result was at any time possible is difficult to see, since the situation in which the union covering this particular trade stands, or does not stand, with reference to those covering the printing industry is a complex one. Conferences were held at the Ministry of Labour last Monday. On Tuesday, the matter was considered by the Conciliation Committee of the Joint Industrial Council for the printing and allied trades, and the point in dispute is to be submitted to arbitration. In the meantime, the men who went out have resumed work, and all notices which had been issued have been withdrawn.

The following are figures of cost per ton of coal disposable commercially, recently issued by the Mines Department for the quarter ended September 30, 1922, relating to the United Kingdom coal mines :—

Costs of Production :	*s.*	*d.*
Wages	11	4·48
Stores and timber	2	1·72
Other costs (management, salaries, insurances, repairs, office and general expenses, depreciation, &c.)	3	1·46
Miners' Welfare Fund contributions	0	1·09
Royalties (including the rental value of freehold minerals where worked by the proprietor)	0	6·43
Total costs	17	3·18
Deduct proceeds of miners' coal	0	1·10
Net costs	17	2·08
Proceeds :		
Commercial disposals	18	3·08
Balance :		
Credit	1	1·00

The output per man-shift worked was 17·94 cwt., and the earnings per man-shift worked were 9*s.* 3·97*d.* The quantity of coal raised in the period was 58,717,767 tons, and the number of men employed 1,027,853, or an average tonnage of 57 tons per man.

COLOMBO DRAINAGE WORKS*

By RICHARD EUSTACE TICKELL, O.B.E., M.Inst.C.E.

COLOMBO is a municipality of about 300,000 inhabitants with a habitable area of 5,725 acres, the average density being 52 per acre. It is bounded on the west by the sea, and on the east by swamps at sea level; and the interior of the city rises to heights of about 100 ft. Such topography presented peculiar difficulties in dealing with the drainage, which were accentuated by tropical rainfalls approaching the rate of 6 in. per hour.

The drainage scheme was constructed by instalments, owing to financial considerations. The first instalment dealt with about a quarter of the area draining towards the harbour. It was commenced in 1902, and formed part of a complete scheme for the whole city. The scheme consisted of a partially separate system of sewers and rain-water drains in every street, the sewers gravitating to pumping stations at approximately 20 ft. below sea level, and the rain-water drains running to the nearest outlet available. The sewers have a capacity of six times the dry-weather flow, reckoned at 25 gallons per head per day; and this capacity has proved so far ample for dealing with such rainfall as is collected from yards. The rain-water drains were designed to take discharges ranging from 1 in. to 2 in. per hour according to the proportion of buildings and garden land. At the pumping stations the sewage is lifted into main sewers, where it gravitates to terminal pumping stations and treatment works.

In November, 1911, the boundaries of the municipality were extended eastward and southward, and, in addition to this increase of area, the census of 1911 disclosed a growth of population which outstripped all records and affected the calculations based upon previous forecasts. In the original scheme, the whole of the sewage was to be dealt with by one terminal pumping station and treatment works, situated at Madampitiya, at the extreme north of the municipality, with an outlet into the River Kelani, about 2 miles above the mouth. In order to deal with the new conditions and to provide for the possibility of still further extensions southward, it was decided to recast the scheme and to establish a southern outfall and treatment works at Wellawatte, with an outfall into the Indian Ocean.

The municipality is now divided into 10 drainage areas, with a pumping station in each, including the two terminal stations at the northern and southern outfalls. The main sewers were laid out so as to collect sewage by direct gravitation from the greatest possible area, which amounts to 2,768 acres, or nearly half the city. The eight subsidiary pumping stations deal with the outlying drainage areas, totalling 2,957 acres, from which the sewage has to be pumped twice.

The estimate for the whole scheme amounted to 23,500,000 rupees, or approximately 1,567,000*l.*; but in 1914 a commission appointed by the Ceylon Government (under whose auspices the scheme had been inaugurated and administered) reported the municipality to be unable to meet the interest on the drainage loan. It was therefore necessary to curtail the expenditure; and, owing to the slow progress in house connections, it was decided to postpone indefinitely the construction of further street sewers, and to substitute a programme of arterial drainage in the uncompleted districts. Main sewers and pumping stations only were constructed, and a system of public latrines was established, with pail-tipping depots on the sewers for the disposal of night-soil collected by carts. The primitive pail system, which exists in all Oriental cities, will therefore be continued, although to a diminished extent; but the depot, which was a prolific breeding-ground for flies and a serious menace to health, is now being finally abolished.

Treatment Works.—At the time of the inception of the scheme, bacterial treatment had been only recently established in Europe, and its application was quite new to the tropics. The system first adopted consisted of septic tanks, sprinkling filters, and storm-water beds. These were first put into operation on the completion of the harbour drainage area in September, 1910. In 1913 this instalment became overtaxed by the extensions of the sewers; and, owing to the tropical climate, the ebullition of gases in the septic tanks was found to be excessive. Large masses of sludge were brought to the surface and carried over the outlet weirs, choking the filters. When the construction of the second instalment was commenced, double-storey sedimentation tanks were adopted, and they have effected a reduction of about 71 per cent. of the suspended solids. The effluent contains about 6 parts per 100,000, which is considered quite good enough for discharge into the Kelani River without secondary treatment. When their success had been established, the original septic tanks were adapted for double-storey treatment by the construction of thin longitudinal partitions sloping transversely towards the side walls at about two-thirds of the depth of the tank. These tanks effect a reduction of 70 per cent. to 80 per cent. of the suspended solids.

Wet-weather tanks, designed on the same principles, have been added, each of which will deal with a dry-weather flow of 335,000 gallons of strong sewage per day, and when the sewage is diluted by storm-water they deal with a flow of 2,000,000 gallons per day each. They produce an effluent containing only 4 to 6 parts of suspended solids per 100,000 during normal flow, and when dealing with six times this volume have given an effluent with 8 to 10 parts of suspended solids per 100,000.

The works up to date have cost 18,000,000 rupees, or 1,200,000*l.* Sixty-one per cent. of the area of the city is provided with street sewers, 28 per cent. with arterial drainage, and 11 per cent. remains to be dealt with. One hundred and twenty-eight miles of sewers and rain-water drains have been constructed. Since the first instalment was brought into general use in 1911, the average death-rate has fallen from 33 to 27 per thousand, a reduction of 18 per cent.; and Colombo is now believed to be the healthiest city in the tropics.

* Abstract of a paper to be read before the Institution of Civil Engineers, on Tuesday, February 20.

SEWAGE DISPOSAL.*

Evolution in Sewage Disposal, with Special Regard to South African Experience in Sludge Treatment, Particularly at Pretoria.

By FRANK WALTON JAMESON.

RECENT evolution in sewage-disposal may be conveniently regarded as having taken place in three stages: (1) The Cameron-Exeter septic-tank process; (2) the Emscher-Imhoff and the Travis process; (3) the process applied in Birmingham by Mr. J. D. Watson, M.Inst.C.E.

Mr. Watson used the Dortmund tank as a secondary sedimentation-tank for liquor from first treatment in a rectangular tank. In Pretoria, however, Mr. Watson's design of circular tank is used to separate organic matter from crude, not settled, sewage. This ensures a flow of sweet sewage on to the oxidising-beds, and the sludge is dealt with in an entirely separate septic tank.

Pretoria Sewage-Scheme.—The system has been in operation for 10 years. The population is 40,000, of which 10,000 are dealt with by pail removal. The whole flows to the outfall works, and the sewer is designed to take the whole storm-water drainage. The rainfall is 30 in. per annum. For dry-weather treatment of septic effluent 7½ acres of heavy loam fallow soil are used, while for wet-weather treatment 10 acres are required. Sludge is dried during the nine-month dry-weather period, and is afterwards mixed with phosphates and used as manure. Pail contents are discharged into the main sewer, which is in process of flushing at the time. A proportion of 20 gallons per pail, or a total of 54,000 gallons of water per day, ensures that the septic pail-content is considerably purified. The works are divided into four complete compartments, and each deals with 333,000 gallons per diem. Sedimentation-tanks have a capacity of one-sixth of the total daily volume entering each compartment. The oxidizing-beds deal with 150 gallons per square yard per diem, the 6-ft. depth of material being broken granite on half-round tiles. Each septic tank has a capacity of one-quarter of the daily volume entering the compartment. No. 1 tank was filled with sludge in approximately 12 months, and, after a period of 12 months' rest, the sludge was comparatively dry. The sludge leaving the sedimentation-tanks contains about 96 per cent. of moisture, and 16,000 gallons pass per diem. Sixty per cent. of the total contents entering the septic tank is retained at each operation, and the ejections on to fallow land occur twice daily. One (dry) ton of sludge is produced every day.

Experience.—A difficulty occurred with the original grit-chamber, as septic action took place in the grit-sump. By substituting a level floor, 27 ft. by 6 ft., and using a water depth of 4 in., the trouble was overcome. Removal of grit by hand is done in 2–3 hours daily. The Watson sedimentation-tanks are circular for a depth of 5 ft. and coned for 25 ft. Sludging is normally carried out at 7 a.m. and 3 p.m. It is required more often in warm weather, to prevent the occurrence of septic action in the lower part of the cone. If this is not attended to the effluent is affected, and the oxidizing-beds are damaged. The supernatant liquor from the Watson tank is collected in the dosing tank, which also acts as a grease-trap by the introduction of baffles. Colloid matter deposited in the channels of the oxidizing-beds is easily removed with a hose. The matter passes on to the land and is rapidly digested. This only requires to be

* Abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, February 20.

done annually. The author considers that, if one bed of four is used as a stand-by, an almost indefinite life may be expected. A bed chosen for rest is left for two months during dry weather. To cleanse the bed of humus, dosing with effluent is carried out at the end of this period. The bacterial life-cycle thus having been reorganized, gradually increasing doses of sewage are applied. A more thorough cleansing of the media is done, if required, by an endless cup chain and grading-screen; washing is not found necessary.

On account of calls for economy, it was decided to discharge the stercus from pails as ordinary sewage at the outfall works. Within a year of the commencement of this practice, the functioning of the oxidizing-beds was affected. Decomposition of the pail contents occurred before the effluent reached the stercus-tank, and partial incubation of fly-pupæ also took place. As a remedial measure the stercus discharge period was fixed to take place between 2 a.m. and 5 a.m., and between these hours the sewage was passed directly from the sedimentation-tanks on to land. Within 15 months of this diversion of the stercus flow from the oxidizing-beds, the latter regained their efficiency. Flies are dealt with by spraying the dried sludge with a solution of arsenite of soda.

Various Types of Septic Tank.—The first design had the outlet at the shallow end, and was fitted with floating scum-boards. These disturbed the sludge during filling. In the second design the shallow end became the inlet, and the scum-boards were removed. "Dry sludge" formed about the outlet level, and "wet sludge" below. The tank is used for intermittent fill and discharge for twelve months, and then rests twelve months. At this time the fertilising value of sludge was discovered, and a third system with a movable outlet-pipe was introduced, to provide an increased output of sludge. The outlet was made to follow the liquor line of the tank. The disturbance which was set up by incoming liquor was not yet overcome. The fourth system consisted in keeping the outlet and inlet open at the same time. Experiments are being carried out at present whereby the liquor is allowed to flow uninterruptedly from the septic tank. In the fifth system dry sludge is removed from the upper layers in the tank to make room for the fresh layers to be built up from underneath. With one or two months' drying on the ground this is ready for grinding for manure. During the war a steam plant capable of digesting carcases was erected, to provide phosphates for mixing with the powdered sludge and improving its value as a fertiliser. Further experiments are in hand to dry sludge from the Watson tank on deposits of household rubbish. The author hopes that the use of the septic tank may be confined ultimately to the wet weather.

MAIN DRAINAGE OF THE SOUTHERN SUBURBS OF THE CITY OF CAPE TOWN, SOUTH AFRICA.*

By DAVID ERNEST LLOYD-DAVIES, M.Inst.C.E.

THE district served by the main-drainage scheme adopted after the unification of the municipalities of the peninsula covers 30 sq. miles. About 15 sq. miles are built on and sewered by this scheme. Though the land falls fairly evenly to the sea, large tracts are subject to floods in winter, and, as prevailing currents are unfavourable for sea outfalls, a gravitation scheme was not possible. Five main intercepting sewers, totalling 17 miles, concentrate at a main pumping-station. The sewage from the low-lying districts, when proposed sub-pumping-stations are complete, will be elevated to the main system. The sewage is finally pumped through a 4-mile rising main to the disposal-works. The scheme is designed, with extensions, to accommodate a population of 290,000, although the present figure is only 81,355. Storm water is dealt with on the partial separate system, and the sewers discharge sewage proper plus rainfall from 100 sq. feet per house. For the determination of the limiting gradients, 25 gal. per head per diem—the maximum average daily consumption—was taken as a basis of calculation. The gradients chosen secure minimum velocities exceeding 3 ft. per second for the small pipe sewers, and 2 ft. per second for the larger culverts.

Sewers.—The maximum capacity is based on the ultimate maximum flow of sewage plus the corresponding proportion of storm water. The maximum average summer consumption is taken at 35 gal. per head per diem. Half the total flow in six hours covers the daily variations. Rainfall-intensity curves have been computed so that the sizes of sewers to receive a quantity of storm water, based on observed rainfall-intensities of particular areas, correspond with the times of concentration of these areas, the correct discharge for each sewer being calculated separately. Under 15 in. in diameter sewers are laid with salt-glazed stoneware pipes, and for diameters of 18 in. to 40 in. granolithic concrete tubes, covered with ordinary concrete, are used. Culverts over 40 in. diameter are constructed of concrete *in situ*. Intercepting-traps to house-drains are not employed.

Main Pumping-Station.—The plant is designed to deal with six times the dry-weather flow, surplus storm-water being discharged through overflow outlets into various streams. Before being pumped the sewage passes through detritus-pits. Three 50 h.p. pumps deliver up to three times the dry-weather flow through a cast-iron rising main to the disposal-works, against a head of 52 ft. Surplus sewage during storms is lifted by three 25 h.p. pumps into three stand-by storm-water tanks. These are reinforced-concrete structures, 79 ft. in diameter and 5 ft. deep, the capacity being one-quarter of the average daily dry-weather flow. The diluted sewage is admitted radially, and leaves by a circumferential channel, discharging into a stream. After the rain ceases, the top water is decanted by a floating arm, and the sludge is returned to the pumps for transmission with the sewage proper.

Sewage-Disposal Works.—The system embraces sedimentation and sludge-digestion tanks, percolating bacteria-beds, humus-tanks, and land irrigation, and it is designed to avoid septicisation of the tank-effluent as far as possible in order to secure the best results from the bacteria-beds and to obviate nuisance. The three pairs of double-storey sludge-tanks are of reinforced concrete, 28 ft. in diameter and 34 ft. deep. They deal with the daily dry-weather flow in 18 hours. The combined contents of the upper chambers is 8·33 per cent. of the volume of the daily flow, and the average velocity is 0·64 ft. per minute. The lower twin chambers contain six months' supply of sludge, which, after digestion, gravitates to the pump-well. The bacteria-beds have an area of 2¾ acres. The concrete floors slope towards a central culvert, and the false floors are constructed of perforated concrete slabs resting on concrete cubes. The sewage is sprayed by travelling distributors on to a medium of brushwood. This medium is fairly satisfactory, but it is hoped to improve the functioning of the beds by adding much finer brushwood as the beds subside, to reduce the rate of percolation. The humus-tanks are similar to, but smaller than, the primary tanks. From these the humus is decanted with sludge from the sedimentation-tanks, and pumped to the drying-beds. It is hoped that the difficulty of de-watering the humus, due to its colloidal nature, will be overcome by mixing, but, should this method be unsuccessful, the two can be dealt with separately. The effluent from the humus-tanks is led to a sewage-farm 550 acres in extent. The cost of the completed scheme is estimated to be £810,000.

* Abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, February 20.

ROYAL, WHITWORTH AND OTHER SCHOLARSHIPS.—The Board of Education have issued Form 67 U., giving the time-table of examinations in 1923 for Royal scholarships, other awards in science, Whitworth scholarships and Whitworth senior scholarships. The examinations commence on April 30 and end on May 16.

PERSONAL.—Our French contemporary, *Le Génie Civil*, gives publicity to a decree contained in the *Journal Officiel*, according to which Mr. Léon Guillet, the well-known metallurgist, and president of the French Institution of Civil Engineers, has been appointed to the position of Director of the Ecole Centrale des Arts et Manufactures, in succession to Mr. Adrien Bochet, an obituary notice on whom we gave on page 108 *ante*.—The British Reinforced Concrete Engineering Company, Limited, have now removed their branch office at Leeds, the new address being 5, East Parade, Leeds.—Mr. Ainslie Reynolds, M.I.Struct.E., has now joined the Roads Department, London, of the British Reinforced Concrete Engineering Company, Limited.

THE LATE PROFESSOR W. C. VON RÖNTGEN.—Wilhelm Conrad Röntgen, the discoverer of X-rays, died at Munich, on Saturday last, the 10th inst., in his 78th year. Born at Lennep, near Elberfeld in Rhenish Prussia, on March 27, 1845, he studied at the Zürich Polytechnikum, where he took his degree in 1869, and became assistant to Professor Kundt at Würzburg. He took part in Kundt's famous acoustical researches and followed him to Strasburg, taught for a short time at the Agricultural Academy of Hohenheim, in Württemberg, returned to Strasburg, went to the University of Giessen, and was back at Würzburg by 1885, now as director of the Physical Institute of the University. His discovery, late in 1895, of the X-rays, has sometimes been described as accidental. It was in the sense that the discovery of any novel phenomenon must more or less be accidental. Radiations, and especially cathode rays, were at that time being studied in many laboratories, and those studies had received a new impetus when Lenard succeeded, in 1893, in passing cathode rays through the very thin aluminium window of his vacuum bulb into another higher evacuated bulb, several metres in length. Röntgen was making similar experiments. He had wrapped his bulb with black paper; yet a screen of barium-platinum cyanide fluoresced on both surfaces, although standing several metres away from the bulb in the ordinary atmosphere of the room. Röntgen found that paper, wood, ebonite, even metals, were far more permeable to these new X-rays, as he called them, than they were to cathode rays, and that the rays were not deflected by magnets, which deflected cathode rays. He observed that the rays would not interfere with one another, and could apparently not be reflected nor refracted by glass, ebonite, metals, &c., though he suspected that more delicate experiments would reveal effects; he determined many absorption coefficients, and he concluded that his radiations were due to ethereal vibrations of very high frequency, possibly longitudinal vibrations. His first account of these experiments, published in the Journal of the Physico-Medical Society of Würzburg, in December, 1895, gave all these details; this journal being little accessible, however, many of Röntgen's original observations were subsequently rediscovered. The Royal Society of London awarded the Rumford medal, in 1896, jointly to Lenard and to Röntgen; only the former came over to the British Association meeting at Liverpool in 1896, where Röntgen and cathode rays were eagerly discussed. Röntgen received the Nobel prize for physics in 1901. His other work concerned acoustics, dielectrics and electrodynamics, double refraction, heat absorption and effects of pressure on viscosity and refractive index. In 1900 he was called to Munich as director of the Institute of Physics; he retired in 1919.

THE INSTITUTE OF METALS.

THE Institute of Metals has now issued a very comprehensive programme for the annual general meeting to be held in the hall of the Institution of Mechanical Engineers, on Wednesday and Thursday, March 7 and 8. On both days the meeting commences at 10 a.m., and since there are 20 papers, a record number, an afternoon meeting will be held on both days also. The annual dinner takes place on Wednesday, March 7, at 7.30 for 8 p.m., at the Trocadero Restaurant, Piccadilly Circus, W. 1. The following papers are expected to be submitted: (1) "The Mechanical Properties of the Magnesium Alloys," by Mr. Aitchison; (2) "The Ternary System Copper-Aluminium-Nickel," by Mr. C. R. Austin and Mr. Murphy; (3) "Further studies in Season Cracking and its Prevention. The Removal of Internal Stress in 60:40 Brass," by Mr. S. Beckinsale; (4) "The Inner Structure of the Crystal Grain as Revealed by Meteorites and Widmanstätten Figures," by Colonel N. T. Belaiew; (5) "The Constitution of Some Alloys of Aluminium with Copper and Nickel," by Kathleen E. Bingham, and Mr. J. L. Haughton; (6) "Tests on Work-Hardened Aluminium Sheet," by Professor H. C. H. Carpenter and Mr. C. Coldron Smith; (7) "The Recrystallisation of Cold-Worked Cadmium," by Mr. Maurice Cook; (8) "The Constitution and Age-Hardening of the Ternary Alloys of Aluminium with Mangesium and Copper," by Marie L. V. Gayler; (9) Note—"The Extrusion Defect in Brass Rods Extruded from a Multiple Die," by Mr. R. Genders; (10) Note—"The Scleroscope Hardness Test. A New Form of Magnifier Hammer," by Mr. R. Genders; (11) "Volume Changes Accompanying Solution, Chemical Combination, and Crystallisation in Amalgame," by Mr. Arthur W. Gray; (12) "The Heat-Treatment and Mechanical Properties of Alloys of Aluminium with Small Percentages of Copper," by Mr. D. Hanson and Marie L. V. Gayler; (13) "The Density and the Hardness of the Cast Alloys of Copper with Tin," by Mr. Harold Heape; (14) "The Modulus of Direct Elasticity of Cold-Drawn Metals as a Function of Annealing Temperature," by Professor F. C. Lea, Mr. V. A. Collins and Mr. E. A. F. Reeve; (15) "The Hardness of Annealed Copper," by Mr. A. L. Norbury; (16) "The Hardness of Certain Copper Alpha-Solid Solutions," by Mr. A. L. Norbury; (17) "The Oxidation of Metals at High Temperatures," by Mr. N. B. Pilling and Mr. R. E. Bedworth; (18) "The Structure of Eutectics," by Mr. A. M. Portevin; (19) "Some Properties of the Copper-Rich Copper-Aluminium Alloys," by Mr. R. C. Reader; (20) "The Production and Heat-Treatment of Chill Castings in an Aluminium Alloy ('Y')," by Mr. W. Rosenhain, Mr. S. L. Archbutt and Mr. S. A. E. Wells.

ST. BRIDE RADIO AND EXPERIMENTAL SOCIETY.—The inaugural meeting of this society will be held in the Large Hall of the St. Bride Foundation Institute, Bride-lane, Fleet-street, on Wednesday, February 21, at 7.30 p.m., when the president, Captain H. Riall Sankey, C.B., will open the proceedings with a short address, to be followed by a demonstration and general meeting. Visitors are invited to attend and take part in the proceedings.

LONDON, MIDLAND AND SCOTTISH RAILWAY.—The following is the Engineering and Scientific Club, Session 1923–23 syllabus of the London, Midland and Scottish Railway, Horwich Engineering Society: February 19, "A Railwayman's Observations on Naval Engineering Practice," by Mr. A. H. Nash, and "Commercial Motor Bodies," by Mr. T. E. Chidlow; March 15, "Wireless," by Mr. A. P. M. Flemming; April 18, "Grinding"; May 11, Smoker and General Meeting.

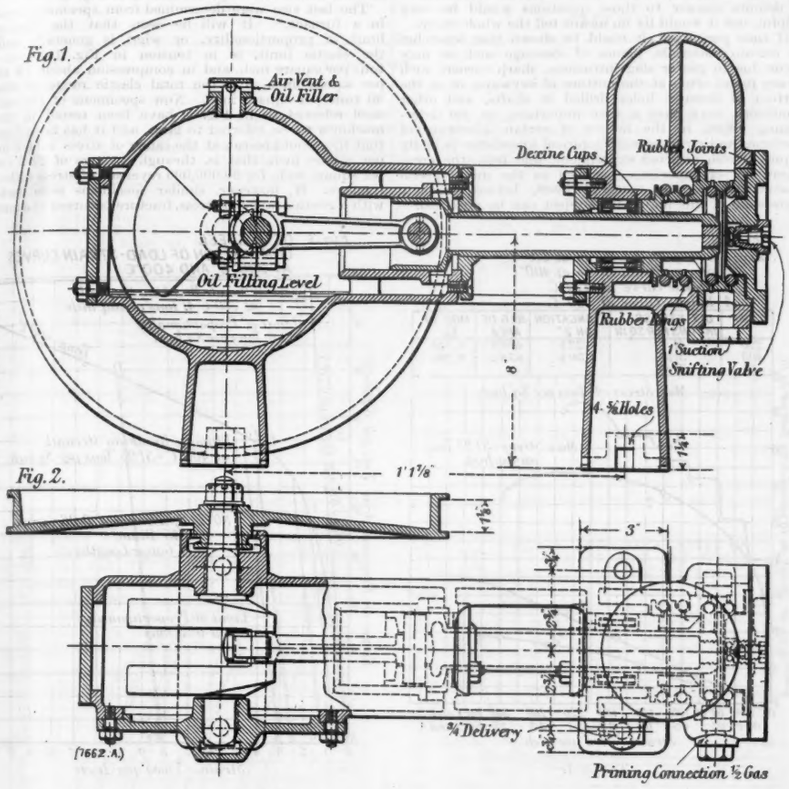
INDUCTION MOTORS.—A course of four lectures on "The Control of the Speed and Power Factor of Induction Motors," will be given at the Institution of Electrical Engineers (Savoy-place, Victoria Embankment, W.C.), by Professor Miles Walker, M.A., D.Sc. (Professor of Electrical Engineering in the University of Manchester), at 5.15 p.m. on Wednesday, February 21, Monday, February 26, Wednesday, March 14, and Wednesday, March 21. Admission—free without ticket.

DROP-VALVE STEAM ENGINES.—With reference to our notice under "Catalogues," on page 126 *ante*, in which we state that the engines referred to, by Messrs. Marshall, Sons and Co., Limited, Gainsborough, range from 15 h.p. to over 900 h.p., Messrs. Marshall inform us that with the coupled tandem compound arrangement they can offer engines up to about 2,000 h.p., and that they have supplied Messrs. William Cooke and Sons, Tinsley, Sheffield, with two rod mill engines of 1,200 h.p. and 1,850 h.p. respectively.

PUMPING PLANT FOR QUEENSLAND.—The Department of Overseas Trade is informed by H.M. Senior Trade Commissioner in Australia that the Metropolitan Water and Sewerage Board of Brisbane, Queensland, is calling for tenders, to be presented by June 26, for additional pumping plant for Mount Crosby Pumping Station, near Brisbane. The contract comprises the manufacture, delivery and erection and setting to work of three pumping units of 6,000,000 gallons capacity per 24 hours, or alternatively, two units of 9,000,000 gallons capacity. The contract also includes the supply of an electrical generator set (140 kw., 440-volt, direct current). A copy of the specification and plans relating to this contract can be inspected by British firms at the offices of the Department of Overseas Trade (Room 50), 35, Old Queen-street, Westminster, S.W. 1.

HIGH-SPEED PUMP WITH RING VALVES.

CONSTRUCTED BY THE PULSOMETER ENGINEERING COMPANY, LIMITED, ENGINEERS, READING.



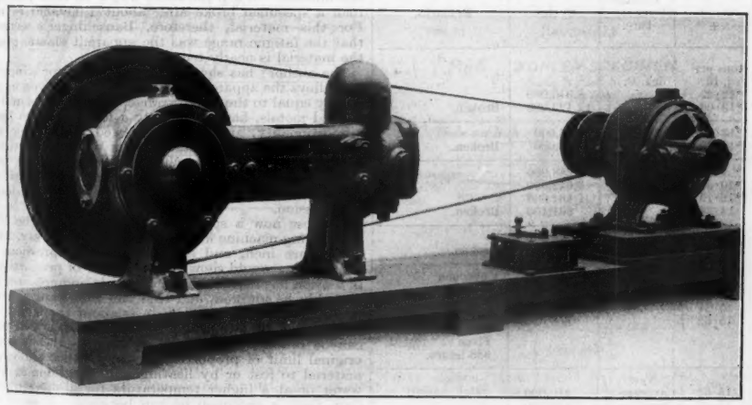
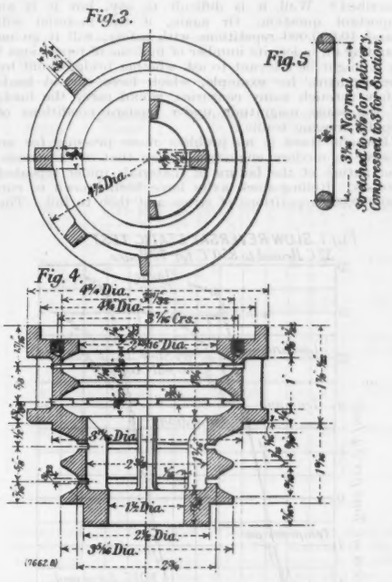


FIG. 6. PUMP ARRANGED FOR MOTOR DRIVE.

THE pump illustrated in Fig. 1 to Fig. 6 annexed, represents a new type which has been designed by the Pulsometer Engineering Company, Limited, of Nine Elms Iron Works, Reading, to meet the demand for an efficient, silent, high-speed pump for small and moderate deliveries. The mechanical features will be readily understood from the drawings. The pump is of the reciprocating, single-acting plunger type fitted with the makers' patent rubber-ring valves, working on gunmetal seats. The seats for both suction and delivery valves are made in one casting which takes the form of a cage surrounding the plunger, as can be seen in Fig. 1. The cage is shown separately in Fig. 3 and Fig. 4, and one of the rubber rings for either the suction or delivery valves is shown by itself in Fig. 5. The valve casting is retained in place by the end cover of the pump and can be readily withdrawn when the cover is removed. The rubber-ring valves work in V grooves in the casting, narrow slits in the bottom of each groove forming the water-ports.

The suction valves are in the internal grooves and work in compression, while the delivery valves are in the external grooves and work in tension. The aggregate area of the water-passages is large, so that the only movement of the valves consists in a very slight compression or elongation of the rubber. The pumps can, therefore, work at very high speeds with absolute silence under all conditions. The stuffing-box is provided with two U-shaped packing rings with the open ends facing one another. They are kept in position by a distance sleeve, and the space between them is exposed to the delivery pressure which automatically keeps the packing rings tight against the plunger. The front of the valve casting enters the stuffing-box and forms a neck ring for the plunger. The pump casing is provided with an air vessel both on the delivery and suction side to prevent shock in the water passages, and a special adjustable snifting valve is fitted in the back cover.

The pump casing is cast in one piece with the enclosed crank-chamber. The front part of the gunmetal plunger acts as a crosshead working on a guide extending into the crank-chamber and thus relieves the plunger and stuffing-box from all side thrust. The



connecting-rod is of gunmetal with a marine-type large end which works on the pin of a balanced crank. The crank-shaft is extended on one side to carry a flywheel pulley or gear wheel as may be required. Removable doors at the side and end of the crank-case give access to the working parts.

Pumps of the type illustrated are built by the Pulsometer Company in sizes to deliver from 250 imperial gallons to 2,000 imperial gallons per hour at heads up to 100 ft. The high speeds at which these pumps are designed to run, namely, from 300 r.p.m. to 500 r.p.m., make them particularly suitable for belt-driving from high-speed electric motors. The enclosed crank-case, with the automatic lubrication of working parts, enables the pumps to run for long periods with no attention, while their compactness and silence, together with the great care taken to prevent oil leakage, makes them suitable for installation in private houses or other places where a nuisance could not be tolerated.

THE EFFECT OF REPETITION STRESSES ON MATERIALS.*

By Professor F. C. LEA, D.Sc., M.Inst.C.E., M.I.Mech.E.

THE problem of determining the fatigue range of materials, and if possible the conditions that determine failure under repeated stresses is a very important one to engineers, especially in view of the greater and greater development of high-speed machinery, and of the possibility of rapidly fluctuating stresses in the elements of structures.

Until about 100 years ago, all engineering experience had been practically confined to structures that would be stressed to some maximum value very occasionally. For example, take a bridge that might possibly have a certain maximum load passing over it once every day. Then to get 1,000,000 repetitions of the maximum stresses produced, it would take nearly 3,000 years, and in between consecutive applications there would be a period of rest amounting to nearly 24 hours, and this period of rest might possibly be very effective in wiping out, if you will allow such a phrase, the effect of any one application. Modern engines may easily run at 2,000 r.p.m. (later we shall have to notice a machine that runs at 4,000 r.p.m.) and the crankshaft of the engine has to pass through cycles of stress every revolution. That is, the stress may pass through a given cycle from compression to tension, or from a certain maximum in tension or through a similar history in compression 2,000 times per minute, or 1,000,000 in less than 24 hours. The crankshaft of a locomotive running from London to Birmingham will make probably 30,000 revolutions in the journey, while the propeller shaft of a ship travelling to America may make probably from 500,000 to 1,000,000 revolutions without stopping. The cross-girder of a railway bridge might conceivably have a train passing over it every 2 minutes, and it may be that axle loads might pass over at the rate of from 6 to 20 per second, followed by a short period of rest. Suppose, then, that a piece of metal is loaded, say, from — 15 tons per square inch (compression) to + 15 tons per square inch (tension) once every day

* Paper read before the Institution of Civil Engineers, Birmingham and District Association, February 8, 1923.

for 3,000 years, it will have had rather more than 1,000,000 cycles of stress. Will that have the same effect on the material, all other things being equal, as though the 1,000,000 cycles had been run in 4½ hours, as is quite possible on the machine to be presently described? Well, it is difficult to say, but it is an important question. Or again, if the material will stand 10,000,000 repetitions with safety, will it go on standing an indefinite number of millions of repetitions? Or it might be relevant to ask whether bridges built by the Romans, for example, which have carried loads safely through many centuries, would carry the loads of the same magnitude under modern conditions of rapidly moving traffic?

Perhaps there is no problem more pressing for an answer in modern engineering than that of the causes and nature of the failure of materials under repeated stresses. Rolling-stock axles have been known to run 400,000,000 repetitions of stress and then to fail. The real difficulty in such a case is to know how many times in its life's history such an axle has passed through the maximum cycle of stress; perhaps only a comparatively few times. Later we hope to show that if a specimen runs with certain cycles of stress below a certain range, then the life may be increased, but if the range of stress is above a certain amount, permanent irredeemable damage is done. In this connection accidental circumstances also play an important part. A number of shafts or wheel tyres respectively may be made of the same material. Some may fail after a short period of running, others may run for very long periods without the slightest sign of failure. As far as can be known, the conditions of running have been exactly the same, and as far as ordinary specification tests of the material are concerned, the material may appear exactly the same. Why failure in one case and not in another?

Wöhler was the first, fifty years ago, to draw serious attention to this question, and to carry out organised tests of materials under repetition stresses. A large amount of empirical data has been gathered together on the ranges of stress through which a piece of material can be stressed in a particular way without fracturing, say, after 1,000,000 repetitions, and it has generally been assumed that if 3,000,000 repetitions can be resisted, then an infinite number would probably be resisted. It will be shown later from tests made in the author's laboratory, that a specimen can resist over 90,000,000 repetitions of a certain range of stress, and then fracture, but that below a certain range of stress more than 200,000,000 million repetitions have been run without fracturing the specimen.

The experimental study of the subject can, therefore, be directed firstly to determine by any means possible that safe range of stress through which a material may be loaded a very large number, perhaps an infinite number, of consecutive repetitions without fracture, and secondly to determine if possible the nature of the failure of the material. Later experimental results will be discussed, but for the moment it will be advisable to consider the nature of the failure. It is well known, for example, that most metals have a crystalline structure, the crystals being of one constituent of the metal imbedded in a eutectic boundary. For example, with the alloys of aluminium and copper, which contain, say, 10 per cent. of copper, the structure may contain crystals of aluminium surrounded by a eutectic of a compound of copper and aluminium, and aluminium. An ordinary piece of mild steel consists of crystals of iron known as ferrite, surrounded by what is generally called pearlite, that is, this surrounding material consists of alternating laminations of carbide of iron, Fe_3C, known as cementite, and ferrite. Now when a piece of steel fails, does it fail by a clean break across the crystals, or does it fail by the crystals separating at the boundaries, does it fail by the material separating under tension, or does it fail by sliding of the crystals at their boundaries in the nature of a shear, or by sliding across the crystals themselves? In other words, does a material fail by shear or by tension, and does it fail by an actual fracture of the crystals, or by separation at the crystal boundaries? A definite answer to these questions would be very helpful, but it would by no means tell the whole story.

If time permitted, it could be shown that scratches on certain materials, planes of cleavage such as may occur due to gas or slag intrusions, sharp corners such as are found often at the bottom of keyways, or at the bottom of threads, holes drilled in shafts, and other conditions, may have a very important, or the determining effect, in the failure of certain elements of machines and structures. Empirical knowledge is badly required from directed experiment, and from the great laboratory of experience, as well as the most careful examination of the material itself, before complete knowledge of this important subject can be obtained.

Fig. 1. SLOW REVERSAL STATIC TEST.
32 C. Heated to 850°C. for 72 Hours

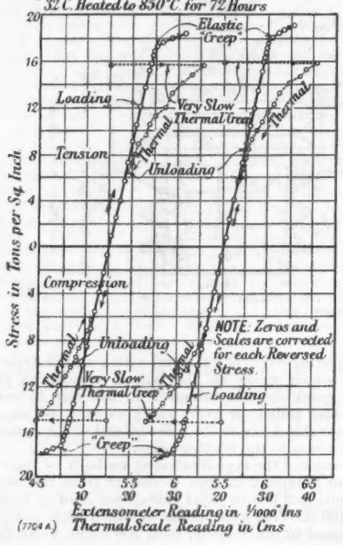


Fig. 2.
Curve 1. Stress Strain Curve at 220°C.
2. Stress Strain Curve at 400°C.
3. Elastic Curve at 220°C.
4. Elastic Curve at 400°C.

TEMP.	ULT. STRESS IN TONS PER SQ. IN.	ELONGATION ON 2"	RED. OF AREA	MOD. OF EL.
220	41	23½	48·3%	11,340
400	31·95	30%	63·4%	8,290
16	26·65			

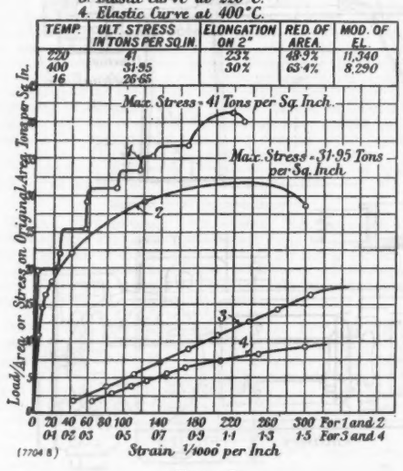

Max. Stress - 41 Tons per Sq. Inch.
Max. Stress - 31·95 Tons per Sq. Inch.
Load/Area, or Stress on Original Area Tons per Sq. in.
Strain 1/1000 per Inch
For 1 and 2
For 3 and 4
(7704 B)

Fig. 3. ·06 C. STEEL
COMPARISON OF LOAD-STRAIN CURVES AT 220°C. AND 400°C.

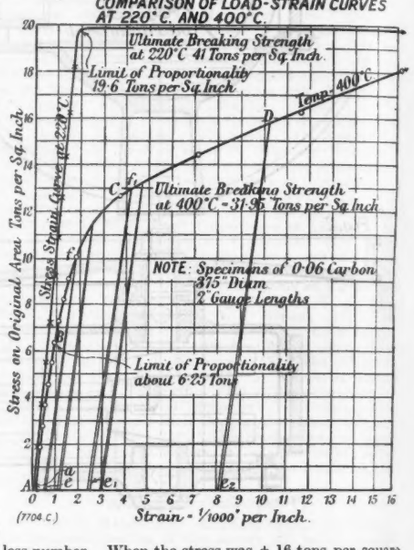

Ultimate Breaking Strength at 220°C 41 Tons per Sq. Inch.
Limit of Proportionality 19·6 Tons per Sq. Inch
Temp. 400°C
Ultimate Breaking Strength at 400°C - 31·95 Tons per Sq. Inch
NOTE. Specimens of 0·06 Carbon .375" Diam. 2" Gauge Lengths
Limit of Proportionality about 6·25 Tons
Stress on Original Area Tons per Sq. Inch.
Strain - 1/1000" per Inch.
(7704 C.)

TABLE I.

Nos.	Stress. ±	Average Temperature.	Cycles.	Remarks.
1	tons per sq. in. *12·25 *13·00	deg. C. 16·0	8,040,000 12,420,000	Broken.
2	*13·00 *13·25	16·5	6,176,000 2,740,000	Broken.
3	* 9·45 *10·55 *12·19 14·24	224·0	11,288,000 6,612,000 1,184,000 601,100	Broken.
4	16·8 17·89	249·0	8,128,000 1,684,000	Broken.
5	14·74 15·08 15·31 15·62	300·0	6,354,000 4,246,000 1,176,000 886,000	Unbroken. Unbroken. Unbroken. Machine and counter broke down. Piece "rested" 688 hours.
5	15·62 15·82 15·84	New average temperature 354·0	410,000 2,610,000 3,020,000	Unbroken.
6	16·1	346·0	228,000	Broken.
7	15·9	369·5	342,000	Broken.
8	15·61 16·09 16·5 17·82 18·25 19·35	390·4	14,280,000 3,104,000 408,000 2,490,000 376,000 430,000	Unbroken. Stopped for 14·5 hours and reloaded cold.
8	Stressed to 20·4 cold	—	112,000	Remained unbroken for tension test.
9	16·75	390·0	3,282,000	Unbroken.
10	15·5 16·64 20·29	390·6	266,000 5,214,000 352,000	Broken.

* All runs are continuous except those marked *.

A further question immediately arises. Can the range of repetition stress of a material be anticipated from a statical test of the material? The load strain curves determined by statical tests in a testing machine for a piece of mild steel containing 0·32 per cent. of carbon, both in tension and subsequently in compression, are shown in Fig. 1, and the load strain curves for two specimens of mild steel containing 0·06 per cent. of carbon, in tension only, are shown in Fig. 2.

The last two were determined from specimens heated in a furnace.* It will be seen that the apparent limit of proportionality, or what is generally called the elastic limit, is in tension in Fig. 1 about 15 tons per square inch, and in compression about 15 tons per square inch, and the total elastic range is about 30 tons per square inch. Now specimens of the same steel referred to in Fig. 1 have been tested in three machines to be referred to later, and it has been found that they could be run at the range of stress ± 14·6 tons per square inch, that is, through a range of 29·2 tons per square inch, for 60,000,000 reversals of stress without fracture. If, however, similar specimens were loaded with a greater range of stress, fracture occurred at a much less number. When the stress was ± 16 tons per square inch a specimen broke after about 1,000,000 reversals. For this material, therefore, Bauschinger's suggestion that the fatigue range was the apparent elastic range of the material is nearly true.

The author† has shown elsewhere that for aluminium cast alloys the apparent elastic range is not even approximately equal to the fatigue range. Alloy steels and cold-worked metals, have frequently a low primitive limit of proportionality, and if time allowed, the author would have wished to give detail results of tests particularly of cold-worked steels, which show that the fatigue range may be much higher than the apparent elastic range when the range is equal in both directions, tension and compression.

Suppose now a specimen of mild steel to be loaded in a testing machine in tension to a stress of, say, 24 tons per square inch, and afterwards in compression, then careful tests would show that the limit of proportionality in tension has been raised, but that in compression it will probably be lowered, and that the total range in which stress is proportional to strain is about the same. It is well known that the limit of proportionality in tension can be raised by overstraining the material beyond its original limit of proportionality and either allowing the material to rest or by heating it for an hour in boiling water or at a higher temperature for a shorter period. Can, then, a specimen be run between the same range of stress the same number of repetitions without fracture independently of the maximum and minimum limits of stress? Many attempts have been made to solve this problem, and various suggestions have been put forward to express a relationship between upper and lower limits of stress, ultimate stress and fatigue ranges, but time prevents more than a reference to it in this paper.

Turning now to Fig. 2, and Fig. 3, it will be seen that the limit of proportionality of the material in tension is about 16·25 tons per square inch, and the yield stress is 19·8 tons per square inch when tested at 220 deg. C., and the limit of proportionality is 6·2 tons per square inch when tested at 400 deg. C., and there is no definite yield-point. The stress-strain curve for 16 deg. C. is not drawn, but the yield stress was found to be about 18·2 tons per square inch. If the materials were tested in compression at these temperatures similar results would be found. But now in repetition tests the extraordinary result is obtained that the range of repetition stress at 400 deg. C. is much higher than at 16 deg. C., and higher than at 220 deg. C. A specimen at 16 deg. C. withstood 8,916,000 reversals at a range of stress of

* See papers by the author, ENGINEERING, October 16, 1914, Proc. Inst. Civil Engineers, 1919–20, Proc. Inst. Mechanical Engineers, 1922; Proc. Inst. Junior Engineers, 1923.

† Proc. Royal Aeronautical Society, 1919.

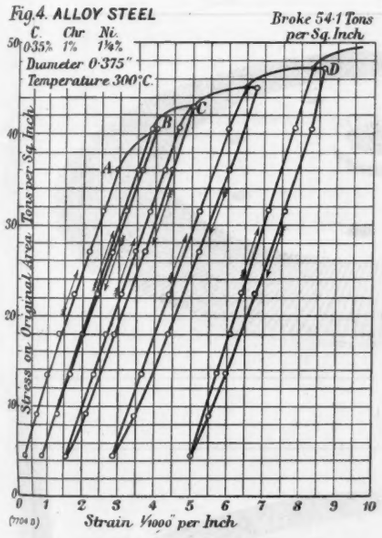
± 13 tons to 13·25 tons per square inch before fracture. A specimen at 16 deg. C. when loaded with a range of stress of ± 19·11 tons per square inch only withstood 6,500 repetitions. When heated to 390 deg. C. a specimen was taken through the cycles shown for specimen (8), point D is reached the stress strain curve is practically, if not quite, the line e_2, D and then along a similar line in compression. It will be seen from Table I that at this stress of 15·61 tons per square inch, over 14,000,000 repetitions were run without fracture, and that the though a specimen has run 50,000,000 repetitions, there is no definite guarantee that some further number will not break the specimen. On the other hand, the results in Table III show that at least as many as 137,684,200 reversals can be run without fracture, and a piece of aluminium alloy ran in the author's laboratory more than 230,000,000 without fracture. The curves in Fig. 5 show, however, that 10,000,000 repetitions will probably give the safe range of stress within an error of 5 per cent.

(To be continued.)

TABLE II.

Sample.	Carbon.	Heat Treatment.	Tension Tests. Limit of Proportionality.	Stress at which there was a Definite but Small Permanent Set.	Yield-Point.	Modulus of Elasticity in Tons.	Ultimate Stress.	Per Cent. of Elongation.	Per Cent. of Reduction in Area.	Hardness. Brinell.	Sclero-scope.	Fatigue. Bending Range Stress.	Maximum No. Repetitions.	Assumed Fatigue Range.	Ratio of Ultimate to Fatigue.
							tons per sq. in.					tons per sq. in.			
T_1	0·14	None	14·96	15·23	15·99	13,100	27·98	38·5	69·3	125	78	±13·81	68·2385×10⁶	±13·8	0·99
T_2	0·14	Heated for 36 hours at 850 deg. C.	15·6	15·84	16·78	12,910	26·45	45·2	64·2	123	73	±14·00	78·52 ×10⁶	±13·8	1·02
T_3	0·14	Heated for 72 hours at 850 deg. C.	15·11	15·26	16·13	12,812	24·65	47·5	59·0	122	74	±15·10	59·327 ×10⁶	±14·9	1·22
T_4	0·14	Heated to 1,100 deg. C. for 1 hour	13·59	13·77	14·08	12,520	23·99	43·1	57·2	115	78	±12·69	55·45 ×10⁶	±12·25	1·02
T_a	0·32	None	16·38	16·62	17·09	13,590	34·45	35·5	65·5	148	84	±14·01	73·5201×10⁶	±14·0	0·82
T_b	0·32	Heated for 36 hours at 850 deg. C.	16·79	16·99	17·34	13,530	32·001	39·4	59·5	143	86	±14·51	78·31 ×10⁶	±14·2	0·89
T_c	0·32	Heated for 72 hours at 850 deg. C.	17·2	17·36	17·66	13,470	31·6	39·0	56·2	140	88	±14·06	60·036 ×10⁶	±14·2	0·90
T_d	0·32	Heated to 1,100 deg. C. for 1 hour	15·4	15·65	15·75	13,260	28·4	34·5	52·0	135	92	±12·21	81·565 ×10⁶	±12·20	0·86

NOTE.—No heat-treatment means no heat treatment after the material left the makers' works. It had been normalised at the works.



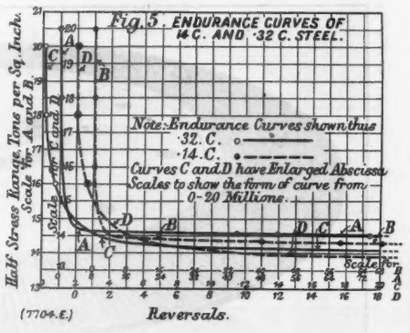


Fig.5. ENDURANCE CURVES OF ·14 C. AND ·32 C. STEEL.
Note: Endurance Curves shown thus
·32. C. ———
·14. C. - - - -
Curves C and D have Enlarged Abscissa Scales to show the form of curve from 0-20 Millions.
Half Stress Range, Tons per Sq. Inch.
Reversals.
(7704.E.)

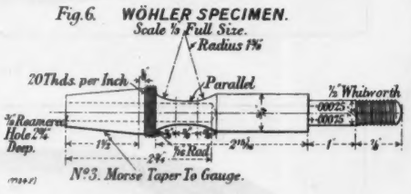


Table I. This table also shows results that have been obtained at various temperatures. On Fig. 2 the ultimate statical breaking strengths for the 0·06 carbon steel at three temperatures are given. These results are by no means complete, and are only preliminary.

It will be seen that although the breaking strength at 390 deg. C. statically considered is a little greater than at 16 deg. C., while in the former case the elastic range is very much less than in the latter, the fatigue limit is very much higher. Is there an explanation? Well, in the first place, I think it can be said that the elastic range can be made at 400 deg. C. far greater than shown by first statical tests. Unfortunately, we have not had time to do a statical test on a piece of 0·06 carbon steel, but Fig. 4 shows a series of stress strain curves for a piece of alloy steel when tested at 300 deg. C. The primitive limit of proportionality in tension was the point A. The steel was overtrsained to B, unloaded, and then re-loaded to C, unloaded and then again loaded to D, and so on. It will be seen that the limit of proportionality follows the maximum stress to which the specimen is loaded. The raising of the limit which takes place at ordinary temperatures with time after overstress, and also by heating in boiling water for an hour, or for 10 minutes at 300 deg. C., is here raised, while the test is going on. The apparent limit has here been raised to 47 tons per square inch, although the breaking strength is only 54 tons per square inch.

In the repetition machine, when testing at high temperatures, the specimen is first brought to the temperature of the test, and then the load gradually applied. The machine is giving 2,000 cycles per minute, and it may take half a minute to get the stress up to, say, 15·6 tons per square inch. Thus the path from A to D, Fig. 3, is not along A B C D, as in a statical test, but is up and down a series of lines practically parallel to A B, such as A B, $e f$, $e_1 f_1$, &c., &c., to the point D. This Fig. 3 only shows what is taking place in tension. When

TABLE III.

Specimen.	Range of Stress.	Reversals.	Remarks.
	tons per sq. in.		
0·14 carbon steel, heated 1,100 deg. C. for 1 hour	±12·25	137,684,200	Unbroken.
0·32 carbon steel, heated at 850 deg. C. for 36 hours	±13·7	96,831,500	Unbroken.
0·32 carbon steel, heated at 850 deg. C. for 36 hours	±14·11	73,620,000	Unbroken.

repetition range was coaxed up to ± 20 tons per square inch without fracture.

A first loading on statical test cannot, therefore, in general give the fatigue range. If a large number of cycles of stress are, however, run either slowly or very quickly as in our machine, the stress strain curves are altered, and the probable range of repetition stress for normalised mild steel at least can probably be interpolated with some degree of approximation from a few cycles of stress. Other methods of determining the fatigue range will be discussed later, and also the point as to whether the fatigue range of a given piece of material can be raised by coaxing, will be considered.

Endurance Tests.—Endurance tests have been run on the specimens, details of which are given in Table II, as well as upon other materials for which space cannot be found here. Fig. 5 shows the results obtained from hollow specimens, Fig. 6, for two types of steel for a number of repetitions varying from a few thousands to more than 80,000,000. The curves show that for the normalised steels a stress per sq. in. of ± 13·8 for the 0·14 carbon steel, and ± 14 for the 0·32 carbon steels is practically the fatigue range, but they also show that even

METROPOLITAN-VICKERS RATEAU MARINE TURBINE.*

By H. L. GUY and P. L. JONES.

(Continued from page 190.)

OF all the various considerations which have to be borne in mind in the construction of an impulse turbine, the design of the discs is of paramount importance. A turbine disc has not only to withstand the centrifugal stresses arising from its own rotation, together with additional stresses introduced by the centrifugal pull of the blades, but also stresses arising from difference in temperature between the periphery and the hub, stresses arising from forcing the wheel on to the shaft, and stresses arising from small vibrations. It is, therefore, of the first importance that the materials should be homogeneous, and it is for this reason that while forged steel, rolled plate and cast steel have all been used by different makers for turbine discs, the Metropolitan-Vickers Company have always confined themselves to the use of forged steel only. The considerations just mentioned require that material used in disc construction should be the very best of its kind, and an elaborate technique of inspection has been built up by which very close watch is kept on those sources of possible trouble which have been revealed by our experience. Two kinds of steel are used by us for turbine discs, these having the following properties, the figures being minimum values:—

Material.	*a*	*b*
Ultimate tensile strength—tons/sq. in.	40	48
Yield point—tons/sq. in. ..	20	30
Elongation—per cent.	22	17
Contraction of area—per cent.	35	40
Phosphorus content—per cent.	Less than 0·05	Less than 0·05
Sulphur content—per cent. ..	,,	,,

The character of the centrifugal stress produced in a turbine disc is shown in Figs. 11 and 12, the former being for the type of wheel adopted in the first stage and the latter representing a typical wheel at the exhaust end of the turbine. As is well known, the stress on the hub varies as the square of the peripheral speed at the outer rim of the wheel and for any given revolutions per minute, the stress equations take the form shown in the right-hand side of these figures on the assumption that the profile of the wheel follows a hyperbolic law. When the profile cannot be sufficiently closely approximated to by a single hyperbolic equation, it is necessary to treat the profile as made up of two or more such curves. The hub can be treated as a thick rotating ring loaded with the radial forces existing at the junction of the hyperbolic profile and the hub. The discontinuity in the stress curves is due to this method of treatment.

If, in place, of riveted fastenings a dovetail or "T" headed rim is adopted, it is necessary to form a bulb rim of proportions indicated in dotted lines in Fig. 12 in order to limit the opening of the jaws to a permissible amount. This additional weight at the rim increases the stresses throughout the disc, the increased value of the tangential stress being indicated by the chain dotted

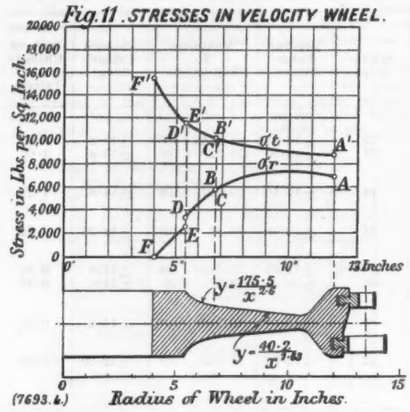
* Paper read before the Society of Naval Architects of Japan, at Tokio, October, 1922.

lines. It might be argued that the stresses in the latter disc can be reduced to the value obtained with a riveted fastening by increasing the axial dimensions of the disc. If such a course is adopted, the pitch of the discs on the shaft is naturally increased. Further, the weight of the disc is sensibly increased, with the result that either the critical speed of the shaft will be brought much nearer the running speed or else the shaft diameter must be materially increased. Increasing the diameter of the shaft is not always possible, and in any case results in increased diaphragm gland losses. Further, the increased bore of the disc results in a further increase in stresses. One is, therefore, caught in a vicious circle, which usually results either in the speed of revolution being reduced or higher stresses being accepted. It is scarcely necessary to point out that the first critical speed of the turbine shaft should be kept at least 20 per cent., and preferably 30 per cent., above the speed at which the emergency governor is set, because marine turbines may be called upon to work for long periods at any lower speed. Further, those designs are to be preferred in which the turbine spindle is supported in two bearings only, because the critical speed can then be accurately determined. For this reason also the spindle should be attached to any other shaft by means of a flexible coupling.

In order to ensure that the wheels shall be tight on the shaft at maximum speed, they must be pressed on the shaft with an interference fit which is greater than the elastic expansion of the bore under centrifugal stresses at maximum speed. This condition can be fulfilled without the maximum stresses in the wheel being greater when the shaft is at rest than the centrifugal stresses at maximum speed, because, when a wheel is pressed on a shaft, the bore of the shaft does not increase by the full amount of the difference between the diameter of the bore and the diameter of the shaft. With wheels and shafts of normal proportions about two-thirds of the pinch fit is taken up in expansion of the bore of the wheel and one-third in compression of the shaft. For instance, in the case of a wheel having a bore 10 in. in diameter, and so proportioned that the maximum centrifugal stress is 8 tons/sq. in. at the tripping speed, the expansion of the bore under this condition will be 0·006 in. In order to ensure tightness the pinch fit must be at least 0·007 in., which will result in a stress when the wheel is stationary on the shaft of approximately 6·2 tons/sq. in., or about three-quarters of the centrifugal stress at maximum speed. If this precaution is not adopted, and the wheels are loose by only a very small fraction of an inch at maximum speed, the bore of the wheel becomes extruded, so that its diameter progressively increases until it is appreciably greater than the diameter of the shaft, thus ultimately producing a loose wheel at all speeds.

Like all elastic bodies, vibration can be set up in a turbine disc when the periodicity of an applied disturbing force synchronises with one of the natural periods of vibration of the disc. A disc can vibrate in a great variety of ways. Vibration can take place with any number of nodal circles or any number of nodal diameters. The forms of vibration which give most concern to turbine designers are the umbrella type, and also vibration about two, three or four nodal diameters. Figs. 13, 14 and 15 are reproductions of photographs taken of a disc vibrating about two, three and four nodal diameters respectively. The nodal areas are clearly shown up by the sand which runs from the vibrating portion to the stationary portion of the discs.

Fig. 11. STRESSES IN VELOCITY WHEEL.



$$A - B\sigma_r = -274{\cdot}3\,x^2 + 1240\,x^{1{\cdot}46} - \frac{43260}{x^{1{\cdot}65}}$$

$$A' - B'\sigma_t = -157{\cdot}8\,x^2 + 780{\cdot}5\,x^{1{\cdot}46} + \frac{106800}{x^{1{\cdot}65}}$$

$$C - D\sigma_r = 926{\cdot}4\,x^2 - 553{\cdot}8\,x^{2{\cdot}16} - \frac{35050}{x^{1{\cdot}56}}$$

$$C' - D'\sigma_t = 533{\cdot}8\,x^2 - 312\,x^{2{\cdot}16} + \frac{112300}{x^{1{\cdot}56}}$$

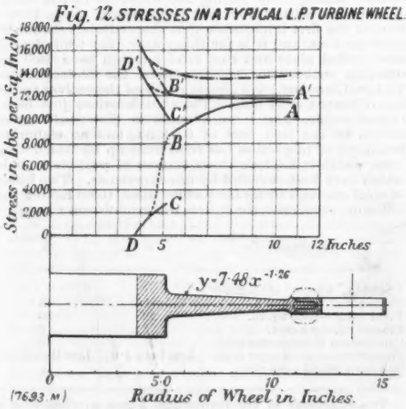
$$E - F\sigma_r = -67{\cdot}28\,x^2 + 8646 - \frac{121300}{x^2}$$

$$E' - F'\sigma_t = -38{\cdot}72\,x^2 + 8646 + \frac{121300}{x^2}$$

$$\sigma_{t\,max.} = \frac{5{\cdot}522}{100}\,u^2 \text{ lb./sq. in.}$$

Poisson's ratio = 0·3.
$E = 30 \times 10^6$ lb./sq. in.
σ_r = radial stress.
σ_t = tangential stress.
u = ft./sec.

Fig. 12. STRESSES IN A TYPICAL L.P. TURBINE WHEEL.



$$A - B\sigma_r = -140\,x^2 + 2880\,x^{0{\cdot}96} - 37700\,x^{-1{\cdot}7}$$

$$A' - B'\sigma_t = -80{\cdot}7\,x^2 + 2026\,x^{0{\cdot}96} + 74500\,x^{-1{\cdot}7}$$

$$C - D\sigma_r = -67{\cdot}2\,x^2 + 8100 - 104000\,x^{-2}$$

$$C' - D'\sigma_t = -38{\cdot}7\,x^2 + 8100 + 104000\,x^{-2}$$

$$\sigma_{t\,max.} = \frac{5{\cdot}13}{100}\,u^2 \text{ lb./sq. in.}$$

Poissons ratio = 0·3
$E = 30 \times 10^6$ lb./sq. in.
σ_t = Tangential stress
σ_r = Radial stress
u = ft./sec.

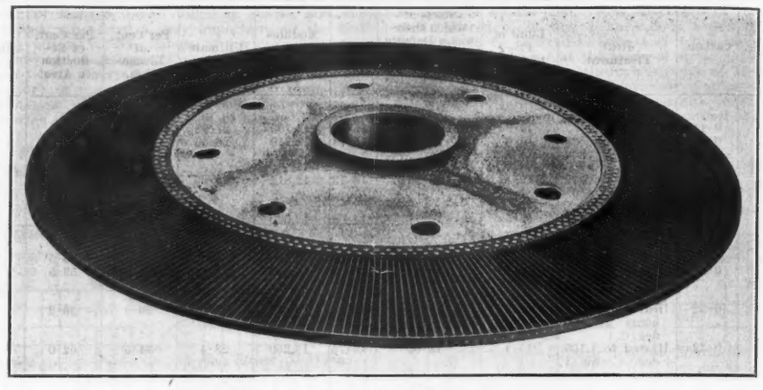


FIG. 13.

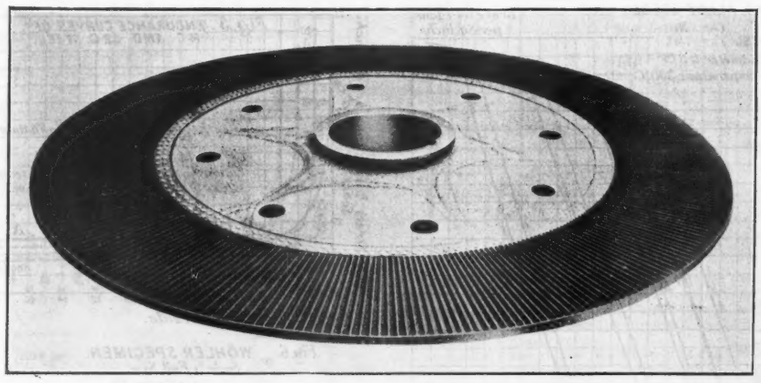


FIG. 14.

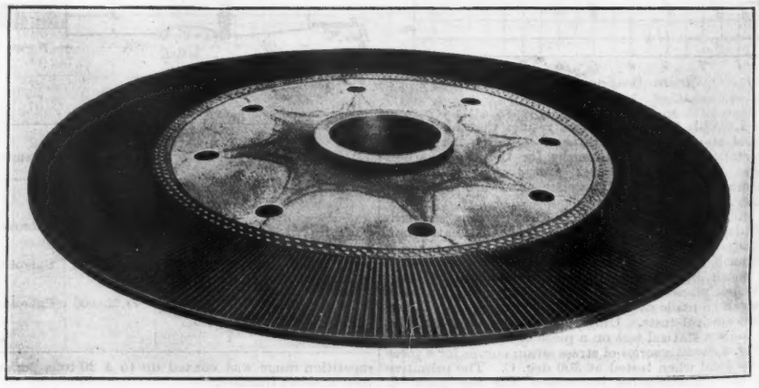


FIG. 15.

The critical frequency of a rotating disc is greater than that of a stationary disc on account of the righting effect of the centrifugal forces. In the case of a parallel disc without a hole, Lamb and Southwell have shown that the critical speed of a rotating disc can be obtained with very small error by a formula of the form—

$$N^2 = a^2 \cdot \frac{h^2}{R^4} \cdot \frac{E}{\mu} + \beta \left(\frac{\omega}{2\pi}\right)^2$$

where h is half the thickness of the disc,
R is the radius of the disc,
E is Young's modulus,
μ is mass per unit volume,
a and β are numerical coefficients,
ω is the angular velocity in radians per second,
N is the vibrations per second.

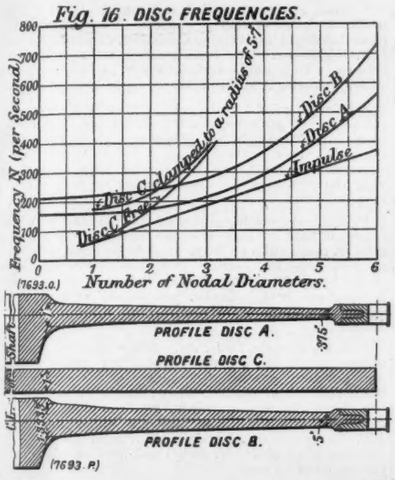
The values of a and β for steel discs obtained by Lamb and Southwell are given in the accompanying tables.

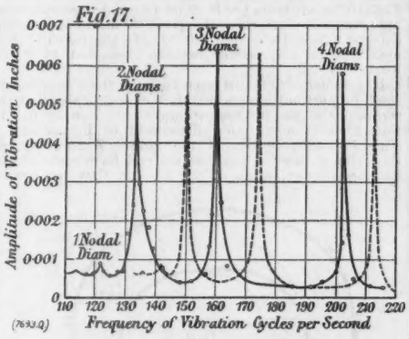
In the above formula for critical speed, the first portion is the square of the critical speed of the stationary disc, whereas the second portion is the square of the critical speed of the rotating disc, neglecting its flexual stiffness. Professor Stodola has developed a graphical analysis by which the critical speed of rotating taper discs loaded with blades at the periphery can be obtained. For such discs the critical speeds can be expressed by a formula of the form—

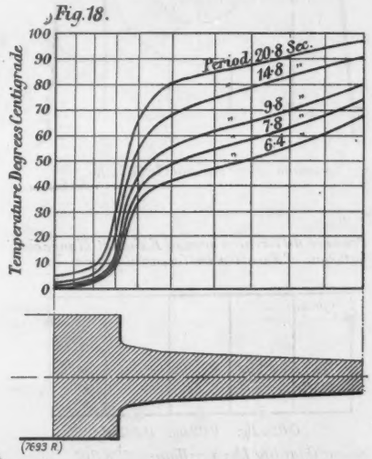
$$N^2 = A \cdot \frac{h^2}{R^4} \cdot \frac{E}{\mu} + B \cdot \omega^2$$

where A and B are constants for any given disc whose value can be obtained by Stodola's method. For similar discs of the same material A and B are constants for the same type of vibration.

The frequencies of vibration of two discs calculated by Professor Stodola's method are exhibited in Fig. 16. The axial dimensions of the disc A are three-quarters of the axial dimensions of the disc B. The frequencies of a third disc C of uniform thickness have also been indicated. Two cases have been worked out for disc C. In the first the disc has been treated as though it were rigidly fixed from the hub to a radius of 5·7 in. In the second case the disc has been assumed to be completely free. On the same figure the frequency of the possible disturbing influences has been added. The relative immunity from any type of synchronous vibration is represented by the vertical intercept between the impulse curve and the vibration curves, *e.g.*, in the case of the disc A it will be observed that the margin between the calculated critical speed with three nodal diameters and the impulses likely to set up vibration of this character is only 11 per cent., while the margin in the case of vibrations about four nodal diameters is 16 per cent. In the case of the disc B it will be noted that the margin is everywhere greater than 40 per cent. It will be observed that in the case of disc C the vertical intercepted between the frequency and the impulse increases very rapidly as the number of nodal diameters increases. It is, therefore, only necessary in discs of this type to investigate the vibration frequencies about one and two nodal diameters.







VALUES OF a.

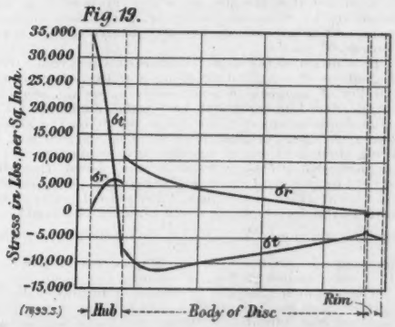
Number of nodal circles.	Number of nodal diameters.			
	0	1	2	3
0	—	—	0·5184	1·20
1	0·8669	1·977	3·353	5·133
2	3·823	5·564	8·153	10·42
3	8·693	11·55	14·74	18·345

VALUES OF β.

Number of nodal circles.	Number of nodal diameter.		
	1	2	3
0	1·0	2·35	4·05
1	5·95	8·95	12·3
2	14·2	18·85	23·85
3	25·75	32·05	38·7

The way in which the critical speed is affected by the dimensions of the disc is illustrated by the following figures, which apply to the discs just considered. If the diameter of the disc is kept constant, the following shows approximately the connection between the thickness of the disc and the critical speed :—

Relative thickness...	1·0	1·1	1·2	1·3	1·4
Relative critical speed	1·0	1·08	1·165	1·245	1·33



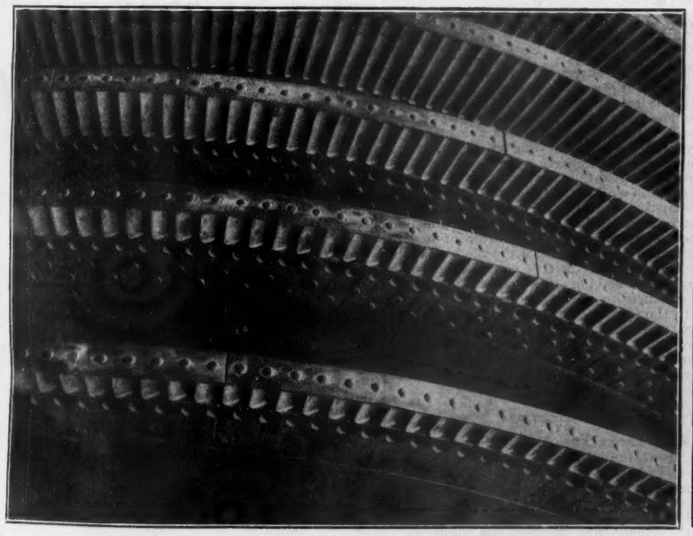


FIG. 20.

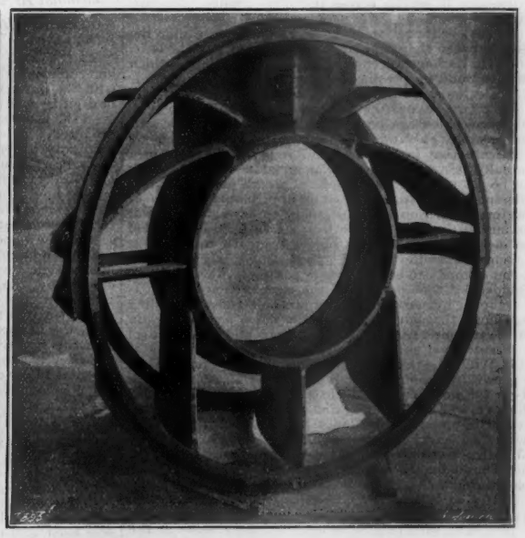


FIG. 21.

If, in series of discs rotating at the same angular velocity, the axial dimensions are the same at the inner and outer radii, and at all corresponding radial distances, the following table shows the relation between the outside diameter and the critical speed :—

Relative outside diameter ...	1·0	1·1	1·2	1·3	1·4
Relative critical speed ...	1·0	0·855	0·735	0·635	0·550

The amplitude of the actual vibrations obtained during the tests illustrated by Figs. 13, 14 and 15 are plotted against the frequency of vibration in Fig. 17. The probable change in these vibrations caused by the centrifugal forces when the disc is rotating at normal speed is shown dotted in this figure. This curve shows

how closely the zones in which vibration can be set up adjoin one another, and it indicates the impracticability of running successfully between two critical speeds. The only safe course is to have an ample margin between any of the different critical speeds, and the impulse which can give rise to them. This margin should not be less than 30 per cent. The test results plotted on Fig. 17 are of additional interest, as recording the fact that vibration about one nodal diameter was distinctly observed. This case is usually neglected by mathematicians as being a type of vibration which cannot be set up.

If the temperature of a disc varies radially a stressed condition is set up in it owing to the tendency to expansion of certain rings in the disc being restrained by others at lower temperatures. When a turbine is warmed up before starting, or when the power developed by it is rapidly changed, or when in the case of a marine turbine it is reversed, the temperature of the outer rim of the wheel is momentarily different from that of the hub. A gradient of temperature is, therefore, established along a radius. Professor Stodola has calculated the radial distribution of temperature in a typical turbine disc for various time intervals after a temperature difference of 150 deg. C. between the outer rim and the hub has been established by raising the temperature of the outer rim. These gradients of temperature are shown in Fig. 18 for a portion of the disc in the neighbourhood of the hub. The maximum stresses which can arise from this cause in the disc considered were also calculated by Professor Stodola and are shown in Fig. 19. In large discs stresses induced in this way may be sufficient to make the discs loose on the shaft, and even to overstress the material. In view of the time interval involved in changing conditions of operation of the turbine, it is improbable that temperature differences of as large an order as 150 deg. C. can be established in a disc, but there is no doubt that the stresses which can arise from this cause are by no means negligible, particularly in large discs, and in cases where they are additive to the normal centrifugal stresses.

In addition to the increased stresses which result from a gradient of temperature along a radius, there is the liability of an unstable condition being set up, resulting in the disc kinking about two nodal diameters. The axial displacement of the extreme points on the kinked disc from their original position may be sufficient to bring these portions of the disc into contact with the diaphragms. Professor Stodola has shown that the critical temperature difference between the outer rim and the hub at which such kinking takes place depends on the ratio of the disc thickness to the radius, and is connected by the relation: $T = A\left(\frac{h}{R}\right)^2$. Where T = constant temperature difference, h = half thickness of the disc, R = outer radius of disc, A = numerical co-efficient.

The common practice of providing balance holes in turbine discs also has an important bearing on the question of disc vibration. When nozzles supply steam around the whole periphery of a disc a small difference of pressure is set up across it. This results from two causes:—

(1) The ejector action of the nozzles on the steam in the space between the disc and the diaphragm in front of it.

(2) The leakage through the diaphragm gland, which tends to build up pressure in this space, because there is no free exhaust from it.

These two actions oppose one another. The pressure difference which can be set up across a disc varies with the pressure existing at that stage. It is found by experience that in most of the low pressure stages in a normally designed turbine, the unbalanced force which can be set up is negligible. In the high pressure stages differences of pressure may cause appreciable end thrust, and for this reason it is customary to provide means of communication, in order to pass steam from one side of the disc to the other, the object being to equalise the pressure across the disc. In those stages where nozzles do not extend around the whole periphery, this means is provided by that portion of the circumference which is unoccupied by nozzles. There are objections to drilling large holes through the face of the discs, particularly in marine turbines, where the speed is not under the control of a centrifugal governor. These objections are:—

(1) While the mean stress in a disc may be reasonable, as shown by the curves in Figs. 11 and 12, at the place where the holes are drilled local stresses are introduced which may be two or three times as great as the mean.

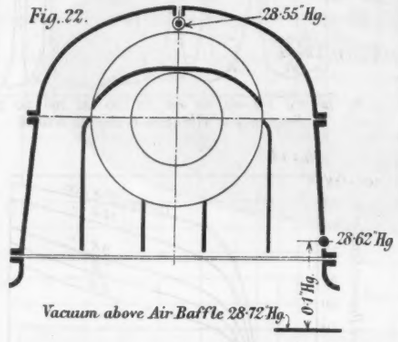
(2) The presence of balance holes increases the tendency of a disc to vibrate.

In the Metropolitan-Vickers marine turbine, these objections have been met by the provision of balance holes through the blades themselves. This construction is illustrated in Fig. 20. It is possible with this design to ensure that the stresses in the blades are not increased by providing such balance holes—*i.e.*, the stresses at the portion of the blade affected can be kept less than in the working portion of the blade.

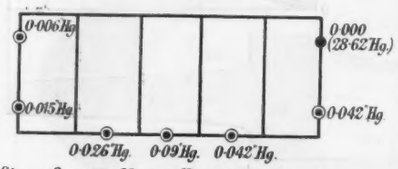
Until quite recently, while every care was taken in providing suitable passages to ensure that the steam moved smoothly along the prescribed path from entry at the first nozzles to leaving the last row of blades, it was allowed to pursue the tortuous path from the leaving edge of the last row of blades to the condenser tubes as best it could. This often resulted in a difference of pressure between the leaving edge of the last row of blades, and the top of the condenser of from ½ in. to 1 in. of mercury or more, corresponding to a loss in efficiency of from 2½ per cent. to 6 per cent. After making tests to ascertain the magnitude of the losses obtained in this way, Metropolitan-Vickers developed an exhaust construction whereby the steam is suitably guided on leaving the last row of blades, and discharged sensibly uniformly over the whole area of the exhaust. In the marine turbine these exhaust guide blades are provided in the diaphragm shown in Fig. 21. That this object has been achieved has been demonstrated by measurements which have been taken on very large exhausts of this type. As the pressure differences are very small, differential gauges filled with paraffin were used. The results obtained on the exhaust of a large turbine when passing 228,310 lbs. of steam per hour into a condenser maintaining a vacuum of 28·62 in Hg. (Bar. 30 in.) at the turbine exhaust flange is shown in Fig. 22. In this case the clear area through the turbine exhaust measured 16 ft. by 6 ft.

If a sufficient exhaust area to keep the loss down to small proportions is provided, it is of such a size that the continuity of the turbine structure is broken by it. In the exhaust construction illustrated in Figs. 3 and 4, page 188 *ante*, certain of the guides Z run through the exhaust, and at the forward end form walls of the turbine support, while at the aft end they are solidly

Fig. 22.



Pressure differences around Exhaust Flange obtained by means of Paraffin Differential Gauges



Steam Quantity Lbs. per Hour	228,310
Exhaust Area Sq. Feet	96
Steam Velocity Feet per Sec. (7693. u.).	316

knit up with the turbine barrel. These ribs, together with the outer walls of the exhaust, form a very strong box girder, with the result that the turbine can carry even the largest condenser with very small stresses being produced. It will further be noted that the steam is uniformly distributed over almost the whole length of the tubes. The exhaust diaphragm shown in Figs. 3, 4 and 21 has the further advantage that whether the ahead or the astern turbine is working, the steam from the last row of blades from the operating section is deflected so that it does not impinge on the last blades of the idle section. As the steam leaving the last row of blades contains a large percentage of water, if the blades on the idle section are not protected in this way they become eroded by the steam leaving the operating section. Further, if the steam from the operating section blows straight across to the idle section, negative work results from the impact, and it has been demonstrated by test that this negative work can reduce the power developed by a reverse turbine, and therefore its efficiency, by as much as 15 per cent.

(To be continued.)

Coal Output in Federated Malay States.—The output of coal from the Malayan Collieries at Batu Arang, Selangor, Federated Malay States, in the first half of last year amounted to 64,921 tons, compared with 148,278 tons in the corresponding period of 1921. The mine is in better working condition now than it has ever been, and the danger from spontaneous combustion has been largely eliminated by the process of sand filling. The decrease in output is due to a falling-off in demand locally.

"Modern Wireless."—We have received from The Radio Press, Limited, Devereux-court, Strand, London, W.C. 2, a copy of the first issue of *Modern Wireless*, a new magazine, the field of which is sufficiently indicated by its name. It is edited by Mr. John Scott-Taggart, and contributors to the first number include Sir Oliver Lodge, Mr. E. H. Shaughnessy, the head of the Wireless Section of the General Post Office, Mr. F. Hope-Jones, and others well known in connection with the art. We read that the new magazine is bound to no society or organisation, but will pursue an entirely independent policy. If it maintains the high standard of its first number, it should hold an assured place amongst the publications devoted to wireless matters, as it is thoroughly interesting and excellently produced.

CATALOGUES.

Dimmer for Electric Lighting.—Particulars of a dimmer for reducing the light of electric lamps for various stages from maximum to bright redness has reached us from the Igranic Electrical Company, Limited, Bedford.

Power Plant Accessories.—A folding card containing illustrations and brief particulars of their combined barometer and vacuum recorder, recording chart, and CO_2 recorders, as well as some useful technical notes and tables, is to hand from the Uehling Instrument Company, Paterson, New Jersey, U.S.A.

Forgings.—Examples of crankshafts, turbine rotor shafts, and general forgings of a similar character, both light and heavy, are illustrated in a catalogue received from Messrs. Clarke's Crank and Forge Company, Limited, Lincoln, who supply such forgings in the rough, rough machined, or finished states.

Transformers.—An index to their pamphlets on transformers has been issued by Messrs. Johnson and Phillips, Limited, Charlton, London, S.E. It is uniform in size and style with the pamphlets themselves, and contains a list of the pamphlet numbers and titles, a list of illustrations and a general index to the contents.

Heating Apparatus.—A catalogue of a small water-heater with boiler and piping circuit or radiator comes from the Wembley Heating Company, Limited, Wembley-Hill, Middlesex. The fuel is fed automatically from a hopper, which holds sufficient for 24 hours' working. The apparatus is suitable for garages, greenhouses, &c.

Mining Switch Gear.—An illustrated descriptive catalogue of automatic sub-stations for mines comes from the Westinghouse Electric and Manufacturing Company, East Pittsburgh, U.S.A. It deals with the controls for a synchronous motor generator set and may, with modifications, be made applicable to rotary converters.

Boilers.—A catalogue giving particulars of a large range of sizes of boilers of the vertical, Cornish, locomotive, multi-tubular, horizontal under-fired, return-tube marine, dry-back marine, and standard marine types, is to hand from the Farrar Boiler Works, Limited, Newark-on-Trent, Tanks, gasholders, air receivers, tip buckets and other examples of steel plate work are also dealt with.

Portable Electric Tools, &c.—Some excellent examples of electrically-driven tools, including drills, grinding and polishing wheels, a circular saw for cane cutting, hand and forge blowers, sirens, and also small motors for driving sewing machines, &c., are dealt with in a catalogue received from Messrs. Cooper and Smith, 110, Cannon-street, London, E.C., who guarantee the machine to be of British design and workmanship. Prices are stated in all cases.

Petrol Engines for Motor Boats.—A catalogue of small petrol engines for motor boats received from Messrs. J. W. Brooke and Co., Limited, Lowestoft, gives particulars of sizes ranging from 3 h.p. to 120 h.p. These engines are built of interchangeable parts so that replacements can be supplied as required. The engines are sold separately, or installations, including reversing gear, tail shaft, propeller, &c., can be supplied as well as completed boats.

Centrifugal Pumps.—A catalogue of single-inlet centrifugal pumps with delivery pipe diameters ranging from 1½ in. to 6 in., and arranged for belt driving or for direct coupling to electric motors, steam engines, or gas engines, is to hand from Messrs. Gwynnes Engineering Company, Limited, Hammersmith, London, W. Full particulars are given of weights, dimensions, disposition of inlet and outlet openings, &c., and a list of parts, which can be supplied for replacements, is also included.

Special Steels.—A neatly printed handbook of 70 pages describing their various steels for tools and constructional work is to hand from Messrs. John Brown and Co., Limited, of Sheffield, and of 8, The Sanctuary, Westminster; London, S.W. All the usual cutting steels are supplied as well as special steels for die blocks, files, toothed gears, aircraft and motor cars. Drills, files, snaps and other finished tools are referred to, but the book deals mainly with the selection of the steel and its treatment in forging and tempering.

Motor Car Handbook.—A pamphlet of some 46 pages, issued by the Sunbeam Motor Car Company, Limited, Wolverhampton, for the instruction of drivers in adjusting, lubricating, cleaning, and the general care and maintenance of the Sunbeam cars is to be commended for clear writing and good arrangement. The writer explains what is necessary, and how it should be done, wisely avoiding any explanation of the car mechanism. Drivers who seek a reputation for keeping their cars in good condition will find this booklet helpful.

Institution of Heating and Ventilating Engineers.—This society was founded in 1898 and has steadily grown until to-day there are nearly 600 members. Although it is one of the smaller institutions there is no lack of enthusiasm among the members, and excellent work is being done by the Research Committee in the endeavour to find solutions to the many difficult problems connected with efficient ventilation. A committee is at present investigating the possibilities of standardisation in connection with fan design and construction. The annual dinner, held on Tuesday last at the Holborn Restaurant, London, under the chairmanship of the president, Mr. J. Watson, gave an opportunity for the review of the progress made by the Institution in its work, showing an excellent record.